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SUPERFUND RECORDS

**FIELD SAMPLING PLAN**

**Preliminary Assessment/Site Inspection**

**• Former St. Louis Ordnance Plant  
St. Louis, Missouri**

Final Submittal

January 2001

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**SUPERFUND DIVISION**

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**Preliminary Assessment/Site Inspection  
Former St. Louis Ordnance Plant  
St. Louis, Missouri**

**Final Submittal**

**Prepared for:**

**U.S. Army Corps of Engineers, Kansas City District  
Kansas City, Missouri  
Contract No.: DACW 41-94-D-9010  
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## LIST OF ACRONYMS

AOI	Area of Investigation
ARARs	Applicable Rules and Regulations
ASTM	American Society for Testing and Materials
BDL	Below Detection Limit
bgs	below ground surface
BTEX	Benzene, Toluene, Ethylbenzene, and total Xylenes
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COC	Chain of Custody
COPCs	Chemicals of Potential Concern
DCE	Dichloroethylene
DO	Dissolved Oxygen
DoD	Department of Defense
DOT	Department of Transportation
DROs	Diesel Range Organics
EM	Engineering Manual
EPA	Environmental Protection Agency
FID	Flame Ionization Detector
FSM	Field Site Manager
FSP	Field Sampling Plan
GC	Gas Chromatography
GMW	Groundwater Monitoring Well
Gpm	gallons per minute
GPS	Global Positioning System
Hanley	Hanley Industry, Inc.
HHRA	Human Health Risk Assessment
HMX	Cyclotetramethylenetetranitramine
HRS	Hazard Ranking System
ID	Inside Diameter
IDW	Investigation-Derived Waste
MCLs	Maximum Contaminant Levels
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
MDNR	Missouri Department of Natural Resource
ml	milliliters
MS	Matrix Spike
MSD	Matrix Spike Duplicate
MSL	Mean Sea Level
NASA	National Aeronautics and Space Administration
ND	Non-Detect
NGVD	National Geodetic Vertical Datum
OD	Outer Diameter
ORP	Oxidation Reduction Potential
OSWER	Office of Solid Waste and Energy Response
PA/SI	Preliminary Assessment/Site Inspection
PAH	Polynuclear Aromatic Hydrocarbon
PETN	Pentaerythritol Tetranitrate

## ACRONYM LIST (continued)

PREscore	Preliminary Ranking Evaluation score
PM	Project Manager
PID	Photoionization Detector
ppb	Parts Per Billion
ppm	Parts Per Million
PPE	Personal Protective Equipment
PVC	Polyvinyl Chloride
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
QCP	Quality Control Plan
QCM	Quality Control Manager
RCRA	Resource Conservation and Recovery Act
RDX	Cyclotrimethylenetrinitramine
R.G.	Registered Geologist
SAP	Sampling and Analysis Plan
SCS	Soil Conservation Service
SOP	Standard Operating Procedure
SOW	Statement of Work
SSHP	Site Safety & Health Plan
TCLP	Toxicity Characteristic Leaching Procedure
USACE	United States Army Corps of Engineers
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VOA	Volatile Organic Analysis
VOCs	Volatile Organic Compounds
WQIPs	Water Quality Indicator Parameters

## 1.0 INTRODUCTION AND PROJECT DESCRIPTION

This Preliminary Assessment/Site Inspection (PA/SI) Work Plan has been prepared by TapanAm Associates, Inc. (TapanAm), under Contract Number DACW 41-94-D-9010, Delivery Order 0002. The PA/SI Work Plan consists of a Field Sampling Plan (FSP), a Quality Assurance Project Plan (QAPP), a Site Safety and Health Plan (SSHP), and a Quality Control Plan (QCP). The FSP describes the procedures for field sampling of various sources and collection of samples along the contaminant migration pathways. The QAPP, SSHP, and QCP describe procedures, review methods, and documentation for data quality objectives, site safety, and quality control (QC) of the project. These documents have been developed in accordance with the requirements specified in the revised Scope of Work (SOW) dated June 1999, and the modified SOW dated August 16, 2000.

In accordance with the United States Army Corps of Engineers' (USACE) SOW, TapanAm is required to conduct a field investigation that produces data to support completion of United States Environmental Protection Agency (USEPA) Preliminary Ranking Evaluation score (PREscore). Further, TapanAm will use the following USEPA guidance documents to develop the sampling program: *Guidance for Performing Site Inspections under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)*, EPA/540-R-92-021, Interim Final, September 1992; and *Improving Site Assessments: Combined PA/SI Assessments*, Office of Solid Waste and Emergency Response (OSWER) Directive 9375.2-10FS, October 1999.

The scope of the PA/SI will include the following:

- ♦ Characterize and evaluate significant site sources;
- ♦ Characterize and evaluate significant pathways;
- ♦ Evaluate releases and targets exposed to contamination; and
- ♦ Collect sufficient data to support the Hazard Ranking System (HRS) and completion of an USEPA PREscore.

### 1.1 PHYSICAL SETTING

#### 1.1.1 Location

The Hanley Area of the former SLOP is located on the western boundary of St. Louis, Missouri, city limits. The facility lies approximately three miles west of the Mississippi River and 0.25

miles south of the intersection of Interstate 70 and Goodfellow Boulevard (ICF, 1991). The site maps are shown on Figures 1 and 2.

### **1.1.2 Physiography, Topography, and Drainage**

#### *Physiography*

The site is located at the western limits of the city of St. Louis, Missouri, which in turn is located on the northwestern flank of the Ozark Plateau in the Dissected Till Plains Physiographic Province (Miller, 1974). The topography of the Dissected Till Plains Province is gently rolling hills with elevations ranging from 500 to 700 feet above Mean Sea Level (AMSL).

Topographic slopes are local reflections of the very gentle regional dip of about 55 feet per mile to the northeast (Harrison, 1997). These gentle dips are interrupted by several narrow zones of deformation which become very intense in some of the zones. Variations in hardness of the Paleozoic rocks are shown by escarpments on the more resistant formations that face southwestward, parallel to the Ozark uplift. The stratigraphy of geologic formations underlying St. Louis County is characterized as sedimentary formations. Glaciers covered the area twice during the Pleistocene, however till deposits in the area are relatively thin and dissected.

#### *Topography*

The Hanley Area consists of 14.68 acres located within the 28-acre former Hazardous Chemical Area No. 2. The Hanley Area is located on a relatively flat terrace with elevations that range from 560 feet to 540 feet above MSL the National Geodetic Vertical Datum (NGVD), 1929. The site topography slopes steeply down to Goodfellow Boulevard along the east side of the site.

#### *Drainage*

More than 85 % of the ground surface at the SLOP site is covered by asphalt, concrete, buildings or other impervious materials (USACE Archives Search Report, 1993). Site terrain slopes toward the southeast and eventually drains into the Mississippi River.

### **1.1.3 Meteorology**

The consistent pattern of climate in St. Louis County consists of cold winters and long, hot summers (Benham, 1979). The moist air from the Gulf of Mexico interacts with drier continental air in the spring and early summer producing heavy rains. The total annual precipitation is 33.8 inches. Thunderstorms occur on about 50 days each year with most occurring in the summer. The prevailing wind is from the south.

The average summer and winter temperatures are 77°F and 33°F, respectively. The average relative humidity in mid-afternoon is about 60 %. Average seasonal snowfall is 18 inches.

### **1.1.4 Soils**

The soil matrix at the Hanley Area of the SLOP site is characterized as an Urban land-Harvester complex, 2 to 9 % slopes according the U. S. Department of Agriculture, Soil Conservation Service (SCS), 1979. This complex consists of approximately 65% urban land with intermingled areas of gently sloping and moderately sloping well-drained Harvester soils.

The urban land of this complex is covered by streets, parking lots, buildings, and other structures that obscure or alter the soils such that identification of the series is not feasible. The Harvester series consists of deep, moderately well drained soils on uplands. These soils formed in 12 to 40 inches of reworked loess fill material over truncated or buried loess soils. Permeability is moderately low in the Harvester soils with slopes ranging from 0 to 20 %.

### **1.1.5 Geology**

Geology of the region surrounding the SLOP site is essentially that of flat-lying sedimentary rocks, mostly limestone and dolomite. Rocks range in age from Precambrian to Holocene. The forces that produced the Ozark uplift controlled the regional structure of bedrock geology in the area (ICF, 1991).

#### **1.1.5.1 Regional Geology**

Regionally, the sedimentary rocks were deposited in shallow epicontinental seas (Miller, 1974). The present structural attitude of the rock units is the result of the compressional, tensional, and uplifting forces, which moved and altered units from their original depositional positions. The

Precambrian rocks, the Lamonte Sandstone, and the lower part of the Bonneterre Formation are the only units that do not outcrop in the area, but are present in the subsurface. Table 1 is a description of stratigraphic sequences in the St. Louis area. (Miller, 1974). Figure 3 shows the geologic map of in the vicinity of the site (Harrison, 1997).

#### *Overburden*

Alluvium deposits underlie the floodplains and terraces of the Mississippi, Missouri, and Meramec Rivers and extends over 277 square miles in St. Louis, St. Charles, and Jefferson Counties (Miller, 1974). The thickness of the alluvium is variable because of irregularities in the bedrock surface upon which it was deposited. The maximum known thickness of alluvium is 150 feet in the Columbia Bottoms near the mouth of the Missouri River. The alluvium is composed of clay, silt, sand, and gravel that in general becomes coarser grained with depth.

Modified loess is thickest along the bluffs and ridgetops. These deposits are generally 40 to 80 feet thick and consist of a clay-rich lower loess overlain by a silt-rich upper loess. These deposits were derived from glacial sources that were deposited during the Wisconsin Stage of the Pleistocene.

#### *Bedrock*

Regionally, bedrock in the St. Louis area ranges in age from Ordovician (430 million years old) to middle Pennsylvanian (300 million years old). Mississippian age rocks of the St. Louis and St. Genevieve Formations lie unconformably beneath Pennsylvanian strata. The St. Louis area has a monocline structure that gently dips to the northeast. The structural attitude of the beds results from the compressional, tensional, and uplifting forces, which created a series of faults and fractures throughout the region.

### **1.1.5.2 Site Geology**

#### *Overburden*

The overburden in the adjacent uplands, located approximately 1000 feet northeast of the Hanley Area, consists of yellowish-brown clayey silt (loess) and ranges in thickness from 13 to 28.5 feet (see Appendix K for boring logs). A sand and gravel layer, containing chert nodules, was encountered beneath most of the former Shell Plant Area near the interface between the



overburden and weathered shale bedrock. This permeable layer provides a potential preferential pathway for contaminant migration in the overburden groundwater. It is unknown if this sand and gravel layer exists beneath the Hanley Area.

### *Bedrock*

As previously stated, bedrock beneath the site is controlled by the Ozark uplift which is evident in the anticlinal, synclinal, and fault zone structures located in the area (Figure 4). The SLOP site is located approximately 1.5 miles east of the Cheltenham Syncline on the downwarped eastern limb and approximately 2.5 miles and 5 miles west of the Florissant Dome and the St. Louis fault zone, respectively. Two earthquake epicenters, magnitudes 1.5 mq (11/30/74) and 3.1 mq (9/20/78), were recorded approximately 10 miles north and south of the site, respectively.

Early Pennsylvanian age rocks of the Marmaton and Cherokee Groups make up the uppermost bedrock strata beneath the Hanley Area and are thought to be approximately 100 feet thick (ICF, 1991). These Pennsylvanian units unconformably overlie the Mississippian-age rocks of the St. Genevieve Limestone, which in turn unconformably overlies the St. Louis Limestone (Harrison, 1997). Regional subsurface structure, interpreted from boring and well logs, is shown in cross-section A-A' (Figure 5). This line of cross-section is located approximately 10 miles north of the SLOP site. It is anticipated that the bedrock strata beneath the site dips to the west-southwest, towards the axis of the Cheltenham Syncline.

## **1.1.6 Hydrogeology**

### **1.1.6.1 Regional Hydrogeology**

Large amounts of fresh water are stored in the bedrock and alluvium underlying the St. Louis area (Miller, 1974). Water occurs in the bedrock along fractures and bedding planes, in solution cavities in the limestone and dolomite, and in voids between the grains in sandstone. Major alluvial aquifers in the area are the water-saturated sands and gravels in the basal part of the alluvium underlying the floodplains of the Mississippi, Missouri, and Meramec Rivers. The alluvial aquifers are recharged by infiltration of stream water during sustained high-river stage and flooding, by direct precipitation, and by underflow from underlying and adjacent bedrock.

The bedrock aquifers receive recharge from precipitation falling directly on the area (Miller, 1974). Movement of water from the soil and subsoil into the bedrock takes place along fractures and solution openings in the rock.

Bedrock aquifers are divided into 5 groups (Table 1) and are as follows:

- ♦ Post-Maquoketa includes all bedrock above the Maquoketa Shale, which probably acts as a confining bed in the St. Louis area (Miller, 1974);
- ♦ Kimmswick-Joachim includes all aquifers between the base of the Maquoketa Formation and the base of the Joachim Formation and is not considered a good aquifer due to insufficient well yields to be considered an aquifer;
- ♦ St. Peter-Everton includes the St. Peter Sandstone and the Everton Formation;
- ♦ Powell-Gasconade includes all units in the Canadian Series of Early Ordovician age; and
- ♦ Eminence-Lamotte includes all units below the base of the Gasconade Dolomite.

Wells drilled into the bedrock aquifers in the St. Louis area encounter confined, or artesian, groundwater. Under artesian condition, recharge to bedrock aquifer mostly occurs from precipitation falling directly on the outcrop area but it may also occur from infiltration through the overburden aquifer within the site area if the two aquifers are hydraulically connected. The hydrostatic pressure, or 'head', in these aquifers raises the water level in the well above the point where it was first encountered during drilling. Any movement of groundwater is from areas of higher hydrostatic pressure to areas of lower hydrostatic pressure (Miller, 1974). This is exemplified by the Missouri Department of Natural Resources (MDNR) well search results which noted production well, log number 003522, to be located approximately 7 miles northeast of the site. This well is 655 feet deep, terminating in the Mississippian-age Burlington-Keokuk Limestone, and had a yield of 120 gallons per minute (gpm) and a static water level of 65 feet below ground surface (bgs) on the date of installation in February, 1936 (Appendix K).

#### **1.1.6.2 Site Hydrogeology (Overburden Aquifer)**

There are no shallow domestic wells, production wells, or monitoring wells located at the SLOP site. As mentioned previously, soil borings were drilled to investigate the overburden, at a location approximately 1000 feet northeast of the site. However, only one of the 9 boring logs, SWMW-7, had an initial recorded water level of 12 feet bgs.

It is anticipated that groundwater will be encountered in the overburden beneath the site at depths ranging from 15 to 45 feet bgs, largely dependent on the seasonal recharge from precipitation. Groundwater in the overburden is anticipated to flow downgradient to the east along the erosional bedrock surface (see Figure 2).

## 1.2 SITE HISTORY

### 1.2.1 Site Background

The construction of the SLOP was completed in May 1942. The area west of Goodfellow Boulevard was used for explosive production and storage. Hanley Industry, Inc. leased this area for receiving, loading, pressing, and testing of explosives. Hanley operated this site from 1959 through 1979. In 1960, the U.S. Army Reserve Center was formed south of the Hanley area and acquired the Hanley area in 1979. The former SLOP was operated during World War II, the Korean War, and the Vietnam War.

The Hanley Area is located on a relatively flat terrace covering most of the 14.7 acres. All of the buildings present in the Hanley Area (production Buildings 218A, 218B, and 218C; warehouse Buildings 219A, 219D, and 219G; and the frame buildings located inside the concrete-walled explosive containment bunkers are in a state of poor repair (ICF, 1991). The site contains a number of underground rooms, tunnels for service utilities, an underground wastewater system, and a storm-water collection system. Currently the former Hanley Area is owned by the Army Reserve Center. Previous building description and uses (USACE Archives Search Report, 1993) are as follows:

#### *Building 218 Series*

Series 218 A, B, and C buildings are large T shaped brick buildings with anti-static floors in all 34 rooms that open to the building exterior. These buildings are interconnected by underground tunnels, which are connected to the basement rooms of each building. These buildings were used for primer and tracer mixing (1941-1945) and loading and mixing of explosives (1959-1979). Delay powder was loaded in the basement of 218A, under room 105. Other uses includes non-explosive storage and burning of explosive contaminated rags.

### *Building 219 Series*

Buildings 219A, D, and G are large, single story, rectangular, brick buildings with a large control room with smaller rooms at each end. All rooms have orange colored glazed brick interior walls, anti-static composition floors, and wall and ceiling vents. The buildings have outside loading docks but do not have basements. Primer and tracer mixing took place in these buildings from 1941-1945. Smokeless powder was loaded throughout building 219A. Buildings 219D and 219G were used for administrative space from 1959-1979.

### *Building 219 Series*

Buildings 219B, C, E, F, H, and J are square, one room brick buildings with orange colored glazed tile interior walls and anti-static floors which were used as magazines. The roofs are clay tiles and 15-foot high concrete blast walls surround each of these buildings. Buildings 219B, 219C and 219H were used for open air drying of explosives from 1959-1979, whereas during this time 219E was used for lead azide production. Buildings 219F and 219J were used for burning of explosives. Buildings 219A, D, and G were used as laboratory buildings.

### *Building 220*

Building 220 is a large rectangular, one-story brick structure that was used for administrative space (1941-1945) and subsequently as an explosive laboratory (1959-1979). All rooms on the ground floor have orange colored glazed brick interior walls and anti-static compound floors. The basement of building 220 is a single large room that was used as a machine shop.

### *Building 227 Series*

The 227-series buildings consist of small one room, white buildings constructed of plasterboard interior walls, asbestos shingle outer walls, and anti-static compound floors. Each building is surrounded by a 15-foot high concrete blast wall approximately 18 inches thick. Explosives mixing operations took place in these buildings from 1941-1945. From 1959-1979 these buildings were used for the storage of sealed explosive containers.

### *Building 228 Series*

The 228-series buildings are of two types. Those at the eastern end are square brick buildings with orange colored glazed brick interior walls and anti-static compound floors. The buildings at the western end (228W, 228X, and 228Y) are long, rectangular structures with plasterboard interior walls and asbestos shingle outer walls. Building 228Z is an open bay. All of the 228-Series buildings are surrounded by a 15-foot high concrete blast wall. These buildings were used for powder storage (magazines) from 1941-1945, then abandoned.

### *Building 236*

Building 236 is a one-story brick building with a concrete floor and a double-car garage. This building was thought to have been used as a garage from 1941-1945, after which time it was not used.

## **1.2.2 Project History**

As stated in the previous section, the Hanley Area was used for research, development, manufacture, and testing of various explosives. Most of the buildings were used for loading detonators and primers and for explosive mixing.

In 1979 decontamination procedures were required to be conducted by Hanley as part of the lease termination. The extent of decontamination, and procedures used, were not well documented. The walls in the buildings were apparently washed down to a height of 8 feet above the floor. The wash water being discharged onto the ground outside the buildings. None of the magazines were washed down. The powder wells installed in 1941 received wastewater from buildings and magazines until 1945. These powder wells provided sedimentation collection before discharge to the sanitary sewer. Hanley was reported to have not used the existing powder wells located on the property.

## **1.3 SUMMARY OF EXISTING SITE DATA**

Three environmental investigations and one archive search report have been conducted at the former SLOP site, Hanley area. Previous investigations at the site include:

- ♦ "USATHAMA-Battelle Columbus Laboratories, June, 1981;
- ♦ "USATHAMA- Environmental Study", ICF Technology, Inc., November, 1991;

- ♦ "Site Investigation Report, Former SLOP, St. Louis, Missouri", Harza Environmental Services, Inc., December, 1998.

In 1981, Battelle surveyed the area for explosives and heavy metal contamination. ICF Technology, Inc. conducted a field screening survey to quantify the extent of asbestos and soil contamination in 1991. The USACE compiled an archives search report for SLOP in 1993. Further field investigation was performed by Harza in 1998. The results of the field sampling activities are described in the following sections.

### **1.3.1 USATHAMA-Battelle Columbus Laboratories, 1981**

In 1981, Battelle surveyed the area for explosives and heavy metal contamination in and around 7 buildings, 54 magazines, 28 powder wells, and 5 sewer locations. The findings showed heavy metal residues to be present on the interior surfaces of all buildings and in the aqueous discharge of the sewer system. Additionally, explosive residues were found on the interior of several buildings and magazines and in the water of several powder wells draining buildings 218A and 218B. Swipe samples for heavy metal analyses were composited by building number and magazine group and were reported in micrograms per square meter ( $\mu\text{g}/\text{m}^2$ ). Heavy metal concentrations ranged from below detectable limits to 24, 147, 32, and 102  $\mu\text{g}/\text{m}^2$  for silver, nickel, mercury, and cadmium, respectively. Lead and chromium were found in all of the buildings surveyed. Concentrations of chromium ranged from 26 to 515  $\mu\text{g}/\text{m}^2$ . Lead concentrations ranged from 800 to 27,200  $\mu\text{g}/\text{m}^2$ . Magazine 219E housed Hanley's lead azide reactor. Magazine 219F, used for open burning of explosives, had the highest lead concentration of 5,840 mg/kg. Concentrations of silver, mercury, and chromium were below detectable limits in all sewer samples.

Explosive residues were found on the walls in buildings 218A, 218B, 218C and 220 as well as Magazines 219C, 219H, 227J, 227M, 227O, 228C, and 228F. Explosive residues were also found in the standing water present in the powder wells draining buildings 218A and 218B. No explosives were found in the discharge of the sewer system. The presence of explosive residues in 218A, 218B, and 218C coincides with the explosive loading, mixing, and disposal operations that were conducted in these buildings from 1941 to 1979. Magazines 219C, 219H, 228C, and 228F were found to contain trace amounts of Cyclotetramethylenetetranitramine (HMX) in residues sampled from the

magazine interiors. The explosive chemical 2,4,6-Trinitrophenylmethylnitramine (Tetryl) was found in the water from the 7 powder wells draining buildings 218A and 218B with levels 4.0 and 4.6 ppb, respectively (Battelle, 1981).

### **1.3.2 USATHAMA- Environmental Study, ICF Technology, Inc., 1991**

In 1991, ICF collected 29 surface soil samples across the site to evaluate the presence of contamination potentially affecting surface runoff and groundwater. Two water samples were collected within the tunnel system to evaluate surface runoff. Results of the sampling indicated that surface soils are contaminated with lead at levels of concern. Contaminant migration pathways for lead include surface runoff and windblown dust. Water samples collected from the tunnels were contaminated with lead and an explosive, pentaerythritol tetranitrate (PETN) at a level of 20 micrograms per liter ( $\mu\text{g/L}$ ), which was also the method reporting limit. Asbestos containing materials were found to be present in most areas within the Hanley area. A leaking transformer containing high levels of polychlorinated biphenyls (PCBs) was dismantled, protectively wrapped, and was disposed of along with PCB-contaminated soils.

Recommendations included the appropriate management of asbestos in the Hanley area and characterization of powder wells and associated piping for the presence of contamination.

### **1.3.3 Site Investigation Report, Former SLOP, St. Louis, Missouri, Harza Environmental Services, Inc., 1998**

In 1998, Harza collected 21 surface soil samples, 4 sediment samples from the powder wells and sewer system, and 1 water sample from a powder well. The samples were analyzed for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), explosives, and metals. Explosives contaminants were detected outside building 219F at concentrations of 3,300 and 9,730 micrograms per kilogram ( $\mu\text{g/kg}$ ) Cyclotrimethylenetrinitramine (RDX) and 1,480 and 1,700  $\mu\text{g/kg}$  HMX at 0-1 foot and 1-2 feet, respectively.

Metals found in surface samples include arsenic, barium, cadmium, chromium, lead, mercury, and silver. Principal organic compounds that were detected by SVOC analyses are polynuclear aromatic hydrocarbons (PAHs) such as phenanthrene, anthracene, flouranthene compounds, pyrene compounds, benzo(a) anthracene, chrysene, and bis(2-ethylhehl)phthalate.

ICF, 1991, states that SVOCs "were observed at trace levels ( $< 1$  ppm) in the background soil samples" and that "their presence is probably due to the proximity of the sampling locations to an asphalt parking lot". For the non-background samples ICF states that "The PAHs were detected at low levels, probably attributable to constituents present in the fill material". Harza, 1998, stated that SVOC contamination "may not result from past operations at the SLOP". Therefore, no SVOC analyses are planned for this PA/SI.



## **2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES**

This section defines organization, structure, roles, responsibilities and lines of authority for activities associated with the SLOP site. The organization and lines of authority for the site investigation are depicted in a flow chart in Figure 6.

TapanAm has been delegated the task of drafting work plan documents, as well as performing the associated field activities. The project organization has been designed to achieve the above objectives by applying technical and managerial strategies that provide successful completion of the investigation work.

### **2.1 MANAGEMENT AND ORGANIZATION**

TapanAm will carry out the project organizational requirements and management as shown in the organizational Chart, Figure 6. A summary of key personnel and their contact information for this project is shown in Table 2.

### **2.2 PROJECT PERSONNEL**

The project organization personnel described below are those listed in the project organization chart:

Program Manager – Tapan Banerjee, P.E., President of TapanAm, has been designated to serve as the Program Manager for this project. He will provide guidance and oversight of the project manager, and is responsible for the overall technical, financial, and administrative management of the project. He is accountable for technical quality, cost/schedule performance, resource allocation, as well as health and safety issues on this project. He will have direct communication with the USACE project manager.

Quality Control Manager – Robert Graverholt, P.E., has been designated to serve as QC Manager for this project. He will provide oversight and monitor the overall project effort to ensure that appropriate QC policies and procedures are followed and documented. Michael Katzman, P.G. of Katzman Consulting, will perform announced and unannounced QC audits and document reviews

of the QCP and FSP during the PA/SI work. QC functions will be separated from the project team and QC personnel will report directly to the Program Manager.

Project Manager – Siva Sivalingam, Ph.D., will provide project management and supervision of all technical work necessary for this project. He will also proactively manage the performance and deliverables of each subcontractor. As the Project Manager, he will be responsible for the overall management of the PA/SI work and will have the direct responsibility for managing the implementation of all work. He will assign project staff, review project submittals, determine the scope development for selected subcontractors, and will assure that all work is performed in accordance with the work plan. He will also assume the responsibilities of the Program Manager for the project when the Program Manager is unavailable.

Field Site Manager – Mike McKinley, R.G., will report directly to the Project Manager. The Field Site Manager will be responsible for the coordination of all project team members and subcontractors on-site to achieve the project schedule and budget as well as ensure that tasks are being completed in accordance with the PA/SI work plans. He will coordinate and provide the necessary technical assistance for the following activities: direct-push groundwater sampling, installation of temporary piezometers, surface water sampling, sediment sampling, subsurface sampling, hollow-stem auger drilling, monitoring well installation, monitoring well groundwater sampling, and surveying. In addition, he will provide independent technical advice to ensure that the performance goals are met.

Site Health and Safety Officer (SHSO) – Mike McKinley, R.G. will also be the SHSO for this project. The SHSO has the primary responsibility for the project safety and health program. The SHSO oversees the safety of site personnel, monitors health and safety training and medical records of personnel, is responsible for health and safety equipment and procedures, and ensures field activities comply with guidelines established in the SSHP.

Project Staff – TapanAm's scientists, geologists, chemists, engineers and environmental technicians are included in the project staff. These professionals will be used to perform field sampling and supervise subcontractor's activities. They will also participate in evaluating investigation results and preparation of technical reports.

### **2.3 SUBCONTRACTORS**

The list of subcontractors who have been selected for this project is shown in Table 2. The Project Manager, or a designated professional, will provide continuous subcontractor oversight to ensure conformance with contract guidelines, technical requirements, and procedures.

### **3.0 PROJECT PURPOSE AND SCOPE**

The purpose of this PA/SI is to determine the presence of environmental contamination that may pose a threat to human health and the environment. Field activities have been outlined and specific objectives have been developed to complete the goals of the scope. Knowledge of the potential contaminants of concern (PCOCs) is essential in defining specific field activities and their objectives.

#### **3.1 POTENTIAL CONTAMINANTS OF CONCERN**

Potential contaminants of concern for this PA/SI, based on previous analytical results and prior site usage (i.e., munition manufacturing and storage), are metals, explosive compounds, and VOCs. A complete list of PCOCs for the SLOP is located in Table 3-1 of the QAPP.

Metals and explosives contamination of the soil was generally found to be limited to shallow depths, except where potentially introduced to the subsurface through leaking sewer/drain lines. Metals and explosive residues were also found in sediments from sewer lines and powder wells.

#### **3.2 OBJECTIVES**

The PA/SI shall be accomplished by conducting field activities to determine the location and extent of contamination at the SLOP site. The PA/SI field activities include the following tasks:

- ♦ Site preparation which includes brush clearing, weed eating, and location of sample collection points;
- ♦ Video inspection of sewer lines;
- ♦ Collection of soil samples (surface and subsurface);
- ♦ Collection of sewer samples (sediment and water at inlet and/or outlet);
- ♦ Collection of tunnel samples (sediment and water);
- ♦ Collection of background soil and water samples;
- ♦ Groundwater investigation utilizing direct-push technology;
- ♦ Installation and development groundwater monitoring wells (GMWs);
- ♦ Monitoring well purging/sampling using low-flow techniques;
- ♦ Water level measurements;
- ♦ Global Positioning System (GPS) surveying of sampling locations; and

- ♦ Management of investigation derived waste (IDW) and proper disposal.

The specific objectives for each field activity are outlined below.

### **3.2.1 Brush Clearing and Weed Eating**

The purpose of brush clearing and weed eating at the site is to cut grass or remove brush that obstructs a sampling location. If the grass or brush does not interfere with field activities then no weed eating or brush clearing will be performed.

### **3.2.2 Sewer Inspection Survey**

The purpose of the video inspection is to detect significant cracks or breaks in the drains/sewer lines which may have allowed PCOCs to enter the subsurface soil, as well as to locate areas of sediment buildup.

### **3.2.3 Sediment Sampling**

Sediment samples are proposed to be collected within the utility tunnels and sewer system. Sediment samples will also be collected from the 22 powder wells on-site, after they have been desensitized for safe sampling. The powder well samples will be analyzed for metals and explosives. The tunnel and sewer sediment samples will be analyzed for metals, explosives, and VOCs.

### **3.2.4 Surface Soil Sampling**

The objective of surface soil sampling is to determine the presence of metals and explosive compounds around the magazines, laboratories, and process buildings located in the Hanley Area. From previous investigation findings surface contamination is generally thought to decrease with depth, therefore, surface soil samples will be collected from the depth interval from 0-1 foot bgs. Surface soil samples will be analyzed for explosives and metals.

### **3.2.5 Subsurface Soil Sampling**

As described in Section 3.2.2 subsurface soil samples will be collected at locations where sewer lines are cracked or broken, potentially allowing contaminants to enter the subsurface. The depth of sample collection will be from approximately 0-1 foot below the bottom of each individual sewer line. All subsurface soil samples will be analyzed for explosives, metals, and VOCs. Soil screening, utilizing a photoionization detector (PID), will be performed on all subsurface soil samples during sample collection.

### **3.2.6 Direct-Push Groundwater Sampling**

The purpose for direct-push groundwater sampling is to gather analytical data for characterizing the quality of the site groundwater. In order to detect groundwater contamination beneath the site, 15 direct-push borings will be advanced to a depth of approximately 40 feet bgs (anticipated to contact the top of bedrock) using direct-push technology. A temporary, one-inch diameter polyvinyl chloride (PVC) piezometer, with 5 feet of screen, will be installed in each direct-push boring. Groundwater samples will be collected and analyzed for explosives, metals, and VOC compounds.

Static groundwater level measurements will be recorded within the temporary piezometers at each boring locations, using a Solonist water level meter. Groundwater monitoring well locations will be selected based upon analytical results from the direct-push investigation, subsurface soil sampling activities, and video inspection results.

### **3.2.7 Monitoring Well Installation and Groundwater Sampling**

If results from the direct-push groundwater investigation detect contaminants to be above the action levels for USEPA or the Missouri Department of Natural Resource (MDNR) cleanup standards, a 2-inch diameter PVC monitoring well will be installed at 6 locations determined from the direct-push analytical results. The monitoring well groundwater samples will be analyzed for explosives, metals, and VOCs.

The wells will be installed using hollow-stem augers, as discussed in Section 4.2.6. Well development will be conducted at a minimum of 48 hours after well completion. Well development will be accomplished using a surge block followed by pumping until the water quality parameters, i.e., temperature, pH, specific conductance, turbidity, dissolved oxygen (DO),

and oxidation reduction potential (ORP), are stabilized. The purpose for well development is to mitigate the effects of drilling on the formation such as restoring hydraulic conductivity with the saturated zone and removing fine particulates. Monitoring well groundwater samples will be collected at a minimum of 2 weeks after well development. Groundwater sampling will be conducted utilizing low-flow groundwater purging and sampling techniques (USEPA, 1996). Groundwater samples will be collected after the water quality parameters are stabilized, as per USACE requirements.

### **3.2.8 Surveying of Sampling Locations**

The purpose of land surveying is to locate monitoring well positions to the nearest 0.01 of a foot (vertical control) and to the nearest 0.1 of a foot (horizontal control) on-site. All sample locations, except for monitoring wells, will be surveyed utilizing a DeLORME Earthmate GPS receiver.

### **3.2.9 Management of Investigation-Derived Waste (IDW)**

The generation of most IDW associated with this PA/SI will result from soil, sediment, surface water, and groundwater development/sampling activities, as well as decontamination wastewater and personal protective equipment (PPE) used during the field investigation. Analytical sampling results will be used to determine whether the IDW will be classified as sanitary, special, or hazardous waste. Testing parameters required for disposal, i.e., pH, open cup flash point, Toxicity Characteristics Leaching Procedure (TCLP) extraction, etc. will be determined by the disposal facility.

## **4.0 DATA COLLECTION ACTIVITIES**

### **4.1 PA/SI DATA COLLECTION**

TapanAm's approach to accomplishing the PA/SI evaluation will consist of the following:

- ♦ Evaluation of existing data
- ♦ Evaluation of PREscore needs for:
  - ❖ Waste Characteristics;
  - ❖ Groundwater Pathways;
  - ❖ Surface Water Pathways;
  - ❖ Air and Soil Exposure Pathways.

#### **4.1.1 Evaluation of Existing Data**

A summary of the previous investigations at the site is described in Section 1.3. All existing data was reviewed to help determine additional information needed to satisfy PREscore and HRS data requirements.

#### **4.1.2 PREscore Evaluation Needs**

This section describes the data required to evaluate the site using the PREscore, a computer program that automates scoring sites according to the HRS. The HRS score for a site is calculated as the root mean square of the four individual exposure pathway scores. Although all the pathways must be evaluated, only significant pathways will be quantified. Throughout the HRS model, each pathway score is calculated as the product of three factor categories:

- ♦ Waste characteristics;
- ♦ Targets; and
- ♦ Likelihood of release.

The potential presence, or confirmed lack of targets, is used to identify or exclude pathways of concern. Pathways that lack potential targets will not be evaluated further for HRS purposes.

Waste characteristics may initially dominate the evaluation for a site because the presence of hazardous substances, pollutants, or contaminants must be established in order for the evaluation to continue. However, for this site the waste sources are relatively well defined and specific types of hazardous substances are suspected. For the PREscore, the presence and identity of the wastes



need only be confirmed during the PA/SI stage. The pathway-specific waste quantity factors may default to minimum, but significant values and the waste characteristic factor is subject to maximum value caps. For these reasons, complete characterization of all waste sources is often not required to confidently calculate a waste characteristics factor value.

The targets factor category often drives the HRS score of a site because it is generally not subject to maximum value caps. Potential targets can usually be identified easily through review of topographic maps, census data, and site reconnaissance. For this site, only limited information regarding targets is available. Therefore, the focus of this PA/SI will be to identify and confirm all potential targets. Again, pathways that lack potential targets will not be evaluated for HRS purposes.

The likelihood of the release factor category is often the last category to be fully determined because it can be very data intensive, costly, and is subject to maximum value caps. Under the HRS, the surface water, air, and soil exposure pathways are given relatively little significance, except under unusual circumstances. Sites where only a potential to release can be documented because of the large dilution weighting factors applied to targets is one example. Documentation of an observed release to groundwater requires collection of upgradient and downgradient groundwater samples from an aquifer used for drinking water purposes.

#### **4.1.2.1 Waste Characteristics**

PREscore follows the same format as PAscore but allows for more site-specific information and professional judgement to be used. In particular, PREscore allows the input of data regarding specific contaminants that may be onsite, rather than assuming the worst case toxicity, persistence, and bioaccumulation characteristics. The HRS considers contamination to be significant, i.e., observed release or observed contamination, under the following circumstances:

- ♦ If the contaminant is not identified in background samples, an observed release is established when the sample measurement equals or exceeds the sample quantitation limit;
- ♦ If the contaminant is detected in background samples, an observed release is established when the sample measurement is three times greater or more than background concentrations;
- ♦ If sample quantitation limits are not available, the Contract Laboratory Program (CLP) contract required detection limits might be substituted. If CLP contract required detection limits are not available, detection limits may be substituted.

The identification of potential hazardous substances of concern is initially made based on the type of operations conducted at the site and a review of past data collected at the site. During the PA/SI process, TapanAm will collect samples from each source to confirm the presence, identity, and concentration of the hazardous substances of concern.

After the presence and identity of the hazardous substances have been confirmed, TapanAm will assign, on a pathway by pathway basis, toxicity, mobility, persistence, and bioaccumulation characteristics values based on the Superfund Chemical Data Matrix (SCDM). SCDM is an integral part of the PREscore software. If values of some contaminants are not available in the SCDM, TapanAm will evaluate whether additional information could potentially increase the HRS score for the site. Since the SCDM is quite comprehensive and the waste characteristic factor is subject to a maximum value cap, this is seldom the case. Additional research of contaminants will not be conducted unless the data could significantly alter the HRS evaluation.

In addition to the analytical data, other HRS information regarding waste sources is also needed. This information, which is generally more readily available and can be documented during the sampling activities, includes the size (area and/or volume) of each waste source and the containment features, if any associated with each waste source. Some of this information may also be available with the MDNR database. Based on the review of available information, none of the waste sources seem to be contained. Given the stringent standards for establishing adequate containment under the HRS and the condition of other sources, it is unlikely that containment features associated with the site would be considered adequate.

HRS waste quantity data needs for this site may be limited because the waste quantity factor will default to a minimum value. Since complete hazardous constituent data may probably never be fully developed, the minimum waste quantity factor value for all the pathways will probably be 10. It seems that the releases to surface water can be documented, i.e., the minimum waste quantity factor value for surface water pathway will be 100. These likely minimum values combined with caps on the individual pathway scores may result in very limited HRS data requirements regarding waste quantity, since only limited sampling data and readily available source size information will be required.

Based on available information, access to the site is restricted. From a HRS perspective, attractiveness and accessibility determine the likelihood of a soil exposure incident. These factors will be ascertained and documented during the site visit.

#### **4.1.2.2 Overburden Groundwater Pathway**

The overburden groundwater pathway does not appear to a significant HRS pathway. This assumption will be confirmed by determining whether the local residents or water suppliers use overburden groundwater as a source of drinking water. Water suppliers will be contacted and nearby wells will be identified during the sampling visit. If nearby drinking wells are identified, basic information about the hydrogeology of the site will be gathered to assess the potential for a downgradient release to groundwater through review of well logs, regional geologic reports, or previous nearby environmental investigations if available.

If nearby drinking water wells are identified, TapanAm will suggest to the USACE to arrange for sampling of the wells.

#### **4.1.2.3 Surface Water Pathway**

Based on the available information, the surface water pathway may be a significant HRS pathway for the site because a migration route from the site into the utility tunnel and sewer system has been established. However, additional sewer maps are needed to delineate the pathway and identify any potential targets. This information will be obtained during the sampling activities. Depending on the targets identified, additional information regarding wetlands, threatened and endangered species, fisheries, and intakes may be obtained. It may also be required to collect information regarding rainfall, drainage area, soil type, and flood frequency to support a projection of a release.

#### **4.1.2.4 Air and Soil Exposure**

The data needs of air and soil exposure are presented together because there is a overlap in the types of targets evaluated under both pathways. Targets are the most significant and most easily addressed data gap. Additionally, air and soil exposure pathways are generally evaluated based on current site conditions, which may be easier to document than past site conditions. Because the site is located in an urban area, it is likely that a significant number of people live and work in the area. Information about potential sensitive environments is also required. Information regarding odors, and blowing dust/particulate releases will also be collected during the sampling activities.

## 4.2 FIELD DATA COLLECTION ACTIVITIES

Field and sampling activities will be conducted in two phases. Phase I field activities include sewer inspection, soil, water, and sediment sampling, and groundwater sampling using direct-push techniques. Phase II field activities include monitoring well installation, development, purging, and groundwater sampling. Methods for sample analyses are included in Table 3. Table 4 includes a summary of containers, preservatives, and holding times.

### 4.2.1 Surface Water Sampling

#### *Rationale*

Battelle, 1981, collected 5 sewer water samples during their 1980 field investigation, which were analyzed for metals and explosives. None of the sewer water samples exhibited concentrations of explosives above the detection limit. Lead, nickel, and cadmium levels were detected in the sewer water samples. A total of 2 tunnel water samples (SW09 and SW10) were collected by ICF Technology, 1991, during their field investigation and analyzed for metals and explosives. Metals detected above the method certified reporting limits include aluminum, barium, calcium, chromium, copper, iron, lead, potassium, magnesium, manganese, sodium, and zinc. The only explosive detected was pentaerythritol tetranitrate (PETN) at 20 µg/L which was also the method certified reporting limit in SW09. This sample was located outside the study area. The rationale for surface water sampling is to further define the extent and magnitude of explosives, metals, and VOCs in the sewer and tunnel water systems.

#### *Sewer Water Samples*

Three proposed sewer water samples are to be collected during this field investigation and analyzed for explosives, TAL metals, and VOCs. The samples will be collected from 3 separate locations:

- ♦ Building 220 sewer system;
- ♦ Manhole west of Building 219A; and
- ♦ Manhole just west of service drive between Magazines 228F and 227A.

Sewer water draining powder wells (PW16-PW21) from Buildings 218A and 218B will be sampled at location shown in Figure 2.

#### *Tunnel Water Samples*

Six proposed tunnel water samples are to be collected at the same locations where the tunnel sediment samples will be collected (Figure 2) and analyzed for explosives and TAL metals. Analytical data from these samples will provide additional information on the water quality within the utility tunnels beneath the Hanley area.

#### **4.2.2 Sediment Sampling**

##### *Rationale*

Contamination in surface water tends to become diluted or transformed as it travels downstream, whereas contaminants deposited in sediments tend to remain in place. The rationale for sediment sampling is to determine the presence and magnitude of contaminants in sewer sediments, in tunnel sediments, and in powder well sump sediments. During the investigation by Harza, 1998, sewer sediment samples were collected from the sewer between Buildings 218A and 218B and from the sewer at Building 236 and was analyzed for explosives and metals. Explosives were not detected in either sample. Elevated levels of barium (1,180 mg/kg) and lead (1,050 mg/kg) were found in the sewer sediment sample collected between Buildings 218A and 218B.

Tunnel sediments have not been sampled to date. Tunnel water was sampled by ICF in 1991, at which time it was noted that no substantial sediment deposits were encountered within the concrete tunnels. However, in Section 6.5.2 of ICF's 1991 Status Report, it is stated that there was evidence of periodic sediment deposit and removal from water flowing along the tunnel floor.

Sediment samples were collected by Battelle in 1980 from 28 powder wells. The 28 powder well sediment samples were composited into 9 samples that were analyzed for explosives. Only powder well samples receiving effluent from Buildings 218A and 218B contained the explosive Tetryl at levels of 4.0 and 4.6 ppb, respectively. Harza collected powder well sediment samples in 1998 from powder wells located outside Magazines 227M (NS15) and 227K (NS16) which were analyzed for explosives and metals. Explosives were not detected in either sample, but elevated lead levels were noted.

### *Sewer Sediment Sampling*

Six sewer sediment samples will be collected at sewer inlet and outlet locations shown on Figure 2. Sewer sediment samples will be analyzed for explosives, TAL metals, and VOCs. Sewer sediment samples will be collected in conjunction with surface water samples, where present, to help define partitioning of chemicals between the sediment and water.

### *Tunnel Sediment Sampling*

Six tunnel sediment samples will be collected within the utility tunnel system at proposed locations shown on Figure 2. Exact locations of sediment collection will be dependent upon the actual locations of sediment deposition on the tunnel floor. Tunnel sediment samples will be analyzed for explosives and TAL metals.

### *Powder Well Sediment Sampling*

Twenty-two sediment samples will be collected from the powder wells (PW1-PW22) (Figure 2). The sediment samples will be collected by EOD Technology, Inc., after the powder wells have been desensitized. Powder well sediment samples will be analyzed for TAL metals and explosives.

## **4.2.3 Surface Soil Sampling**

A total of 46 surface soil samples will be collected from the site and analyzed for explosives, TAL metals, and VOC constituents. The proposed surface soil sampling locations are as follows:

### *Magazine Series 228*

Three surface soil samples will be taken at locations where building decontamination water was likely to have been discharged to the ground surface around magazines 228 A-G, W-Z, and M. The 3 grab surface soil samples from each magazine, or group of magazines, will be composited and submitted for explosives and TAL metals analyses.

### *Magazine Series 227*

Three surface soil samples will be taken at locations where building decontamination water was likely to have been discharged to the ground surface around magazines 227 A, B, J, M, and O.

The 3 grab surface soil samples from each magazine will be composited for a total of 5 samples submitted for analyses.

*Magazine Series 219*

Three surface soil samples will be taken at locations where building decontamination water was likely to have been discharged to the ground surface around magazines B, C, E, H, and J. The 3 grab surface soil samples from each magazine will be composited for a total of 5 samples submitted for explosives and TAL metals analyses.

*Building 236*

Three surface soil samples will be taken in the vicinity of Building 236 and composited. This composite sample will be analyzed for explosives, TAL metals, and VOCs.

*Building Series 218*

Three surface soil samples will be collected from the each of the unpaved sides of the Buildings 218A, B, and C and composited. A total of 8 composite surface soil samples (3 from 218A, 3 from 218C, and 2 from 218B) will be submitted for explosives and TAL metals analyses.

*Process Buildings 219A, D, and G*

Three surface soil samples will be collected from each of the 3 unpaved sides of the process buildings (i.e., south, west and north sides) and composited. Three composite samples from each building will be analyzed for explosives, TAL metals, and VOCs for a total of 9 samples.

*Building 220*

Surface soil samples will be collected from approximately 0 to 1 foot bgs. The near surface vegetation, if any, or any other obstruction (i.e. gravel or rocks) will be removed before the sample is collected. A decontaminated shovel, spoon, or scoop will be used to remove any obstruction prior to sample collection.

Four surface soil samples will be taken in the vicinity of Building 220. These 4 samples will be analyzed for explosives and TAL metals.

#### **4.2.4 Subsurface Soil Sampling**

##### *Rationale*

Video inspection of the sewer lines will be used to detect significant cracks or breaks in the drains/sewer lines which may have allowed PCOCs to enter the subsurface soil. Locations where cracks or breaks have been detected will be saved as a picture computer file using a '.jpeg' format. Subsurface soil samples will be collected adjacent to the cracks or breaks in the sewers or powder wells to determine the extent of contaminant migration into the subsurface soil.

##### *Subsurface Soil Sampling*

A total of five subsurface soil samples will be collected from locations where the sewer/drain lines have been damaged (determined from video inspection) potentially causing subsurface contamination. The samples will be collected using direct-push technology where possible. Where direct-push sampling is not feasible a stainless-steel hand auger will be used for sample collection. Subsurface soil samples shall be collected approximately 0 to 12 inches below the base of the sewer line. The five subsurface soil samples will be collected from the sampling equipment utilizing the EasyDraw Syringe™ sampling method. Subsurface soil samples will be analyzed for explosives, TAL metals, and VOCs.

#### **4.2.5 Direct-Push Groundwater Sampling**

##### *Rationale*

Although no groundwater has been sampled at the Hanley Area a potential exist for explosives, metals, and/or VOC contamination to have entered the groundwater through soil leaching, utility tunnels, and cracked sewer lines. Fifteen proposed direct-push groundwater sampling locations (Figure 2) have been positioned to assess water quality beneath the site.

##### *Direct-Push Groundwater Sampling*

Continuous soil sampling of the subsurface down to top of bedrock (estimated to be 40 ft bgs) will be performed at 6 of the 15 direct-push boring locations, to aid in defining overburden stratigraphy. In order to detect overburden groundwater contamination beneath the site a 1-inch diameter PVC piezometer, with 5 feet of screen, will be installed in each direct-push borings. Groundwater samples will be collected with a 0.7-inch diameter, 36-inch long disposable



polyethylene bailer and new disposable nylon rope. The groundwater samples will be analyzed for explosives, TAL metals, and VOCs.

Static groundwater level measurements will be recorded at each direct-push boring locations to aid in determining the groundwater flow direction beneath the site. Groundwater sample locations will be selected based on analytical results from the surface and subsurface soil sampling activities, as well as the information provided by the video inspection.

#### **4.2.6 Monitoring Well Installation**

##### *Rationale*

Six permanent monitoring wells will be installed for the collection and analyses of representative overburden groundwater samples at the site. Monitoring wells will be installed in the Hanley Area only if the direct-push groundwater sampling results are above federal or state action levels for individual PCOCs.

##### *Monitoring Well Installation*

Six soil borings will be advanced and converted to groundwater monitoring wells. The soil borings will be advanced to the top of bedrock utilizing 4.25-inch inner diameter (ID) hollow-stem augers. The estimated depth of a monitoring well is 40 feet bgs. The well will be constructed of 2-inch PVC well casing with 10 feet of 2-inch PVC, 0.01-inch mill-slot screen. After setting the 2-inch PVC well casing and screen in the boring, a filter pack (clean #10-20 silica sand) will be placed to a minimum height of 2 feet above the top of the well screen. A minimum 2-foot thick bentonite seal will then be placed above the sand filter pack. The bentonite seal will be placed in 6-inch lifts and each lift will be allowed to hydrate a minimum of 15 minutes prior to next placement of the lift. If the groundwater level in the well is below the bentonite seal, 1 gallon of de-ionized water per 6-inch lift will be used for hydration. The seal will then be allowed to hydrate for 12 hours. The remaining annulus will be grouted to the ground surface with a bentonite grout.

The soil borings/groundwater monitoring wells will be located using the analytical results from the direct-push groundwater investigation. If groundwater contamination is encountered, one monitoring well will be placed upgradient of the contaminant plume, while the other five will be positioned equigradient/downgradient to define the plume boundaries. Field screening with a

PID will be used to monitor split spoon samples from the soil boring. The PID with an 11.7 electron volt lamp, can successfully determine the presence of most volatile organics. Therefore, PID readings obtained from these sampling intervals may complement the groundwater data in assessing potential contamination.

A boring log shall be prepared in the field by a qualified geologist while the boring is being advanced. The logs will be prepared on an Drilling Log (Appendix J) and in accordance with the USACE Borehole Logging Requirements. It is anticipated that the borings/wells will be drilled to a depth of approximately 40 feet bgs. The final boring depth will be determined by field conditions. The geologist present during well installation will prepare the well construction diagrams. Well construction diagrams shall be completed in accordance with Appendix J.

#### **4.2.7 Monitoring Well Development**

##### *Rationale*

Well development is necessary before wells are capable of subsequently being purged and sampled. The rationale for well development includes:

- ♦ Ensure that the well filter pack and formation are in proper hydraulic connection;
- ♦ Remove bridging in the filter pack;
- ♦ Stabilize the aquifer from drilling disturbances;
- ♦ Remove fines generated by the drilling process from the surrounding formation;
- ♦ Remove five times the volume of fluids lost (if any) during borehole advancement (EM 1110-1-4000, August 1994)
- ♦ Prepare the well for sampling; and
- ♦ Ensure data obtained from the well (water level, groundwater quality, etc.) is representative of the overburden aquifer conditions.

##### *Monitoring Well Development*

Well development will be performed no sooner than 48 hours after grout placement. Well development will be conducted by surging and pumping the well in alternating cycles until the water is clear and free of fines. Well surging will be conducted with the reciprocating motion of a surge block in the screened interval.

Surging with a surge block will be employed during development. It is an effective technique for well diameters of two inches or greater, with preferential development where the screen is longer than five feet. A surge block can be used effectively with a bailer or pump so that material that has been agitated and loosened by the surging action is removed. The surge block will be lowered to the top of the well screen and then operated in a pumping action, using a typical stroke length of approximately three feet. Surging starts at the top of the screen and is worked downward through the screened interval. Initially, surging action will be gentle and the energy gradually increased during the development process.

Once the fines have been removed the well will be developed using a submersible pump. The pump intake will be set approximately in the middle of the well screen. The groundwater will be pumped at the low-flow rate through the flow-through cell, until all the field parameters listed below have stabilized. The well is considered properly developed if the water is clear and the groundwater parameters have stabilized to the indicated ranges, as listed below, for a minimum of three consecutive measurements:

- ♦ Dissolved oxygen :  $\pm 0.2$  mg/L
- ♦ Oxidation-reduction potential:  $\pm 20$  mV
- ♦ Turbidity:  $<50$  NTU
- ♦ Specific conductance:  $\pm 25$   $\mu$ S/cm
- ♦ Temperature:  $\pm 0.5^{\circ}\text{C}$
- ♦ pH:  $\pm 0.1$  unit

If a well can not be properly developed within four hours, the USACE project manager will be contacted. The geologist present onsite during development will prepare the well development records for each well. Information to be recorded on well development field sheets is listed in the Appendix J.

#### **4.2.8 Groundwater Sampling**

##### *Rationale*

The low-flow purge and sample method removes water from the well at a very low flow rate, which minimizes drawdown and groundwater velocity into the well also minimizing movement of colloidal particles affecting sample turbidity. The well will be purged at the low-flow rate until the field parameters (temperature, pH, specific conductance, turbidity, DO, and ORP) have stabilized.

*Groundwater Sampling*

Groundwater from the six newly installed monitoring wells will be sampled using the low-flow sampling procedures (USEPA, 1996) outlined in Appendix M.

Personnel will stand up wind of the well while unlocking and removing the well cap. The well will be monitored with a PID prior to taking water level measurements or obtaining groundwater samples. The PID reading will be recorded in a field logbook. Additionally, the condition of each well and flush mount casing will be noted in the field logbook. Water level readings will be measured from the notch or mark on the top of the well casing.

A minimum of two weeks will have passed between the well development and sampling to minimize drilling impact on groundwater in the well. The goal of groundwater sampling is to collect water samples that are representative of existing groundwater in the overburden aquifer. One round of groundwater samples will be collected from each well at the site. Groundwater will be purged and sampled using the low-flow purge and sample method consisting of a submersible QED bladder pump purging the well at a low flow rate (200-500 ml per minute). In case the recharge to the well is very slow, the pump rate will be set lower than 200 ml per minute to maintain the 0.3 feet drawdown in the well, throughout the sampling event. The pump intake is set approximately in the middle of the well screen, with a stagnant water column over the top of the pump. The well is purged at the low-flow rate until the field parameters (temperature, pH, specific conductance, turbidity, DO, and ORP) have stabilized.

The following field parameters will be recorded during purging at five-minute intervals. A minimum of 5 well volumes will be removed prior to sampling. The groundwater parameters will be stabilized to the indicated ranges as listed below for a minimum of three consecutive measurements:

- ♦ Dissolved Oxygen:  $\pm 0.2$  mg/L
- ♦ Oxidation-reduction potential:  $\pm 10$  mV
- ♦ Turbidity:  $<50$  NTU
- ♦ Specific conductance:  $\pm 25$   $\mu$ S/cm
- ♦ Temperature:  $\pm 0.5^{\circ}\text{C}$
- ♦ pH:  $\pm 0.1$  unit

VOC samples will be collected first, followed by explosives then TAL metals. Containers for VOC samples (40 ml volatile organic analysis (VOA) with teflon septum) will be held at an angle and slowly filled to reduce the loss of volatiles. After the container is filled and the cap is placed on the vial it will be tapped so that the entrainment of air is minimized, i.e., so that no headspace exists. If bubbles appear, the sampler may try once to carefully top off the VOA vial. If bubbles persist, the vial should be discarded and the sample collected in a new vial. After the samples are collected in the field they will be sealed, labeled, and immediately placed in a cooler containing ice.

A Well Purging and Sampling Form (Appendix J) will be completed each time a well is purged and sampled.

#### **4.3 SAMPLING LOCATIONS AND FREQUENCY**

Sampling locations and types of samples to be collected are shown in Figure 2. The rationale for choosing sampling locations for each matrix has been previously described. Table 5 lists the sample matrix and number of field and QA/QC samples to be collected during the PA/SI work.

#### **4.4 FIELD QA/QC SAMPLING**

Summaries of the field QA/QC samples to be collected for the primary laboratory (AM Lab) and QA Laboratory (USACE CQAB Lab) are shown in Table 5. QA/QC samples to be collected consists of a blind QC replicate, a QA replicate, a matrix spike and matrix spike duplicate, an equipment rinsate blank, and a trip blank.

#### **4.5 SAMPLING EQUIPMENT, CONTAINERS, AND SUPPLIES**

The list of field equipment, sampling equipment and supplies, decontamination supplies, and sample containers that will be taken to the field is listed in Table 6. Table 4 lists the containers, preservation, and holding times for each analytical method.

All samples collected in the field will be labeled, placed in a cooler on ice, and cooled to about 4°C. Holding times are intended to minimize chemical changes in a sample before it is analyzed. The laboratory will ensure that all samples are analyzed within specified holding times to maintain sample viability. To allow expedient analyses and minimize the possibility of exceeding holding times, samples will be delivered to the laboratory by overnight carriers within one day.

after samples are collected. Samples exceeding holding times and laboratory QA/QC problems will be required to be resampled and analyzed at the laboratory's cost.

#### **4.6 SAMPLE ANALYSES**

Analytical methods for both laboratory and field are shown in Table 3.

#### **4.7 FIELD INSTRUMENT CALIBRATION**

All field sampling equipment that requires calibration will be calibrated prior to each day's use, or as specified in the procedures included in Appendix L.

#### **4.8 INVESTIGATION-DERIVED WASTE**

This section presents the procedures to be followed in the management, characterization, manifesting, and disposal of all IDW waste generated during PA/SI. All IDW will be managed in accordance with Missouri and Federal rules and regulations.

##### **4.8.1 Anticipated IDW**

Based on prior IDW generated at the site, only non-hazardous wastes are anticipated to be generated by the planned field activities. The following is a description of the anticipated waste to be generated at the site during the PA/SI.

##### *Direct-Push, Drilling, and Subsurface Soil Sampling*

Liquid wastes that are anticipated to be generated include decontamination water and monitoring well development water. All liquid wastes will be containerized in 55-gallon Department of Transportation (DOT) approved drums and stored on-site. Excess soil collected for sampling will be combined and stored in 55-gallon DOT approved drums and transferred to the drum storage location.

##### *Groundwater Sampling*

Purge water and decontamination water will be containerized in 55-gallon DOT approved drums and stored on-site.

### *Incidental Wastes*

Incidental solid wastes, such as used PPE and plastic sheeting, will be placed in plastic garbage bags and disposed of in a trash receptacle as solid waste, arranged for by the field site manager.

#### **4.8.2 IDW Storage Location**

All containerized solid and liquid IDW will be stored at the drum storage location.

#### **4.8.3 Container Labeling**

Each drum will be labeled with information regarding the project designation, type of waste, sample location, quantity, date of origin, and physical and chemical characteristics if known. In addition, each waste container will be given a unique number that will be recorded on the drum with a paint pen and in the field logbook.

#### **4.8.4 IDW Tracking**

All IDW will be tracked until disposal. The location, identification number, sample matrix, origin, date of origin, container type, container condition, field inspection dates, field inspector's initials, and final disposition will be recorded in the field logbook.

#### **4.8.5 IDW Sampling and Characterization**

All IDW will be sampled and properly characterized for disposal at the end of the PA/SI. The required IDW analytical samples are listed in Table 5. The IDW sampling procedures are summarized below:

##### *Liquid Wastes*

A total of three samples will be collected from the 55-gallon drums stored on-site. The liquid IDW grab samples will be analyzed for metals, explosives, and VOCs.

##### *Solid Wastes*

A total of three representative grab samples are anticipated to be collected from solid waste IDW drums and placed in eight-ounce jars. Solid waste characterization samples will be analyzed for

metals, explosives, and VOCs. The IDW sample analytical results will be used along with the analytical results collected during the PA/SI in determining disposal requirements. A record of the source drums for each grab sample will be noted in the field logbook.

#### **4.8.6 Disposal of IDW**

As stated previously, only non-hazardous waste is expected to be generated by the planned field activities. All wastes, with the exception of incidental wastes, will be containerized in 55-gallon drums and characterized in accordance with applicable State and Federal laws and regulations.

Upon receipt of the waste characterization results, TapanAm Project Manager will review the results and determine if the wastes are classified as a special or hazardous wastes. A waste profile will be sought from the contract disposal company for each waste type. The waste profiles will be sent to the USACE project manager for review and approval, before the waste disposal plans are finalized.

All liquid wastes (well development, purge water, decon water, etc.) stored in 55-gallon drums will be disposed of in 'bulk' at an off-site licensed facility. Incidental wastes will be disposed of as non-hazardous waste in a trash receptacle. Once the container is full it will be transported to a sanitary landfill as solid waste.



## **5.0 SAMPLE HANDLING AND DOCUMENTATION**

Correct sample handling, record keeping and documentation are required to assure that all samples meet QA/QC requirements. Sample designation, custody, transfer, and documentation are critical issues for proper project QA/QC.

### **5.1 SAMPLE DESIGNATION**

Each sample collected at the project site will be assigned a unique sample tracking number. The sample tracking number will consist of a three segment alphanumeric code that identifies the matrix type, sample location, and QA/QC designator.

Sample labels will be completed at the time the sample is collected and will be affixed to the sample container, either before filling, or immediately following sample collection. This procedure will reduce the risk of potential mislabeling sample containers and assure that all information is complete and ready for documentation.

Sample designators for replicates will only be identified in the field logbook, to insure that the laboratory cannot identify QC replicate sample correlation. QA replicates sent to USACE CQAB Laboratory in Omaha, Nebraska will have same the sample number as the primary sample, but will be given a suffix "QA".

The following sampling codes will be used in this project:

- GW – Groundwater
- IDW – Investigation-Derived Waste
- MW – Monitoring Well
- SED – Sediment
- SUB – Subsurface Soil
- SS – Surface Soil
- SW – Surface Water
- DP – Direct Push
- TUN – Tunnel
- SEW – Sewer
- W – Water
- S – Soil

PW – Powder Well

The last one to three alpha characters is the QA/QC designator and are used as follows:

QA – Replicate sample  
EB – Equipment rinsate blank  
MS – Matrix spike  
MSD – Matrix spike duplicate  
T – Trip blank

The following are examples of sample designation:

#### *Sediment Samples*

The first three-character string, "SED", will designate that the sample matrix is that of sediment. The next three to four-alpha numeric string will designate the sampling location (i.e., sewer, tunnel, and powder well). The last one to three-alphanumeric character string will indicate the QA/QC designators. The following is an example of the sample designation for the sediment samples:

"SED-PW17-EB" – This indicates that the sediment sample was collected from powder well number 17 and that the sample will be analyzed as an equipment rinsate from the sediment sampling tool.

#### *Surface Soil Samples*

The first two-character string, "SS", will designate that the sample matrix is that of surface soil. The next four to five-numerical string will designate the building sample location. The last one to three-character string will indicate the QA/QC designators, which has been previously described. The following is an example of the sample designation for the surface soil samples:

"SS-218A3" – This indicates a surface soil sample was the 3<sup>rd</sup> composite collected from building 218A, and that the sample will be analyzed as a primary sample (does not include QA/QC designator).

### *Subsurface Soil Samples*

The first three-character string, "SUB", will designate that the sample matrix is that of subsurface soil. The next four-alphanumeric string will designate the direct-push boring location. The last one to three-alpha character string will indicate the QA/QC designators. The following is an example of the sample designation for the subsurface soil samples:

"SUB-SEW3-QA" – This indicates a subsurface soil sample was collected adjacent to a sewer line from boring number 3, and that the sample will be analyzed as a QA replicate to be sent to the USACE CQAB laboratory in Omaha, Nebraska.

### *Direct-Push Groundwater Samples*

The first two-alpha character string, "GW", will designate that the sample matrix is that of a groundwater sample. The next three to four -alphanumeric string will designate the direct-push (DP) sampling location. The last one to three-alphanumeric character string will indicate the QA/QC designators. The following is an example of the sample designation for the direct-push groundwater samples:

"GW-DP8-MSD" – This indicates a groundwater sample was collected from direct-push groundwater boring number 8 and that the sample will be analyzed as a matrix spike duplicate.

### *Monitoring Well Groundwater Samples*

The first two-alpha character string, "GW", will designate that the sample matrix is that of a groundwater sample. The next three to four-alphanumeric string will designate the monitoring well (MW) number sampled. The last one to three-character string will indicate the QA/QC designators. The following is an example of the sample designation for the monitoring well groundwater samples:

"GW-MW5-MS" – This indicates a groundwater sample was collected from groundwater monitoring well number 5, and the sample will be analyzed as a matrix spike.

### *Surface Water Samples*

The first two-alpha character string, "SW", will designate that the sample matrix is that of a surface water sample. The next four-alphanumeric string will designate the location and order of sampling collection (i.e., sewer is "SEW" and tunnel is "TUN"). The last one to three-alpha character string will indicate the QA/QC designators. The following is an example of the sample designation for the surface water samples:

"SW-SEW4-T" – This indicates a surface water sample was collected from a discrete sewer location, it was the 4<sup>th</sup> sample collected, and that the sample is a QA/QC trip blank for inclusion in the sample cooler to detect cross-contamination of VOC constituents.

### *IDW Samples*

The first three-alpha character string, "IDW", will designate that the sample is that of investigation- derived waste. The next two alphanumeric string will designate the matrix of the sample, i.e., "W" for water and "S" for soil followed by sample collection number. The last one to three-alpha character string will indicate the QA/QC designators. The following is an example of the sample designation for the IDW samples:

"IDW-S2" – This indicates a soil sample was collected from the 55-gallon drum of soil and was the 2<sup>nd</sup> composite collected. IDW will be analyzed for all parameters reported for the source material.

## **5.2 SAMPLE CHAIN-OF-CUSTODY**

The chain-of-custody (COC) section describes the appropriate sample custody documentation procedures for preparation, handling, storage, and shipping of all samples collected. A sample COC form is included in Appendix J. The possession of samples shall be traceable and maintained from the time they are collected until they are shipped to the laboratory for analyses. As a result, it is important for the field and laboratory personnel to be aware of the need to maintain custody of all samples, whether in the field or in the laboratory. Custody of samples will be maintained on-site by locking the sample cooler in the field vehicle until the samples are shipped to the laboratory. A COC will also accompany the shipper.

A sample is under custody if any of the following conditions exist:

- ♦ It is in the sampler's possession;
- ♦ It is in the sampler's view after being in his/her possession;
- ♦ It is in the sampler's possession and he/she placed it in a secured area;
- ♦ It is in a designated secured area, in a shipping container, or delivered to the courier; and
- ♦ It has been delivered by courier to the laboratory and is in storage at the lab prior to commencement of preparation or testing.

The analytical laboratory will accept any samples for testing purpose with a properly prepared COC form attached with the shipment.

### **5.3 CHAIN-OF-CUSTODY FORMS**

The COC form is used to trace the custody of samples collected or maintained by TapanAm personnel in the field. For the analytical laboratory, the COC form serves as a sample logging mechanism. Details of laboratory COC procedures after receipt of samples is described in Section 5.0 of the QAPP. The COC form will have detailed information as follows:

- ♦ Project number;
- ♦ Project name;
- ♦ Matrix;
- ♦ No. of containers;
- ♦ Test Method;
- ♦ Sample number;
- ♦ Date and time of sample collection;
- ♦ Sample type (composite or grab);
- ♦ Remarks (comments).

The person relinquishing the samples must sign in the designated signature block. A copy of the COC form will be kept with the sample files. Upon arrival at the laboratory, the laboratory personnel will sign in the designated receiving block provided. A copy of the signed COC form from the laboratory will accompany the analytical results.

## **5.4 FIELD CUSTODY PROCEDURES**

Field custody procedures involve several activities which are listed below:

- ♦ After sample containers within a shipping container are packed and filled, the COC form will be completed;
- ♦ The original COC form will be placed in a plastic bag and sealed with a custody seal and then taped onto the inner lid of the shipping cooler;
- ♦ A copy of the COC form will be retained by the Field Site Manager;
- ♦ The original COC form will be transmitted to the Project Manager by laboratory personnel upon receipt of the sample shipment;
- ♦ Receipts from the courier will be retained as part of the COC documentation (i.e., Fed-Ex label).

## **5.5 TRANSFER OF CUSTODY AND SHIPMENT**

All sample shipments will be accompanied by a COC form. Transfer of the possession of samples will require the signatures on the chain-of-custody form of persons who relinquish or receive the samples. A courier receipt or bill of lading will serve in place of the COC signature, since the COC is sealed in the shipping container prior to relinquishing the container to the delivery firm (i.e., Fed-Ex).

Proper packaging of the samples will be performed by securing the shipping containers with strapping tape and custody seals. The custody seals will be placed on the shipping containers so that they cannot be opened without breaking the seals. The seals will be signed and dated by the project personnel who relinquish the shipping containers to the transporter.

## **5.6 DOCUMENTATION**

Standard sample documentation procedures are necessary to maintain control of all sampling activities in the field. When samples are collected for on-site and laboratory analyses, proper procedures to generate, maintain, complete, and verify related paperwork is important in the integrity of field activities. Among the documentation involved are chain-of-custody forms, a field logbook, site safety and health logbook, daily quality control report, and a photographic log.

All original data recorded in the field logbook, COC records and other documentation used in the field will be written in water-resistant indelible black ink. None of these original documents will be altered, destroyed or discarded, even if they are illegible or contain inaccuracies that require correction. Errors made in any field documentation will be corrected by the individual making the original entry. A single line will be drawn through the incorrect information and the correct information entered adjacent to the original incorrect entry. All corrections will be initialed and dated.

#### **5.6.1 Field Logbook**

The field logbooks are used to document field activities involved, all samples collected, time and date of collection, and other important information related to the field project activities.

Information recorded in the field logbook will include, but are not limited to the following:

- ♦ Name and address of site investigation;
- ♦ Name and address of field office contact (POC);
- ♦ Affiliation of persons contacted;
- ♦ Names and responsibilities of all field members;
- ♦ Name and title of author;
- ♦ Date and time of entry;
- ♦ Weather on-site;
- ♦ Names and titles of all site visitors;
- ♦ Type of waste;
- ♦ Date and time of sample collection;
- ♦ Sample collection method (grab or composite);
- ♦ Sample identification number(s);
- ♦ Number and volume of sample(s) collected;
- ♦ Details of the sampling location;
- ♦ Types of field measurement (i.e., pH, specific conductance, temperature, DO, ORP, turbidity, and water level);
- ♦ Time, date, location, description, and log of photographs (if taken) of the sampling points;
- ♦ Information concerning sampling changes, scheduling modification, and variances;
- ♦ Information concerning access agreements;
- ♦ Depth to groundwater and bedrock;

- ♦ Field observations;
- ♦ Documentation of procedures for preparation of reagents or supplies that become an integral part of the sample (e.g. filters and absorbing reagents);
- ♦ Information from containers, labels of reagents used, de-ionized water used for blanks;
- ♦ Sample preservation;
- ♦ Sample destination and transportation (e.g. name of the laboratory and courier);
- ♦ Summaries (analyses requested and containers used per laboratory sample);
- ♦ Summary of daily tasks, cost and documentation on any scope of work changes required by field conditions and necessary approvals;
- ♦ Field equipment or instrumentation used and calibration results;
- ♦ Volume of groundwater removed during development or purging;
- ♦ Decontamination procedures;
- ♦ All sample documentation such as container lot numbers as received from lab, COC record numbers;
- ♦ IDW documentation such as contents and approximate volume of waste, disposal method;
- ♦ Signature and date (entered by personnel responsible for observations at bottom of each page).

#### **5.6.2 Field Logbook Documentation Procedures**

The proper requirements and procedures of documenting the field logbooks are listed as below:

- ♦ Field logbooks should be kept in the field team member's possession or in a secured location (e.g., locked cabinet);
- ♦ A table of contents will be provided;
- ♦ The logbooks will be sequentially numbered with no pages removed for any reason;
- ♦ Each line on the logbook page will contain field information and no lines will be left blank;
- ♦ Single empty lines will be "lined out" with a line placed through them, accompanied by the team member's signature. Multiple empty lines will be "Z'ed out" with a single Z placed through the entire space of empty lines. The team member's signature will accompany the diagonal of the Z;
- ♦ All notebook entries will be recorded with the military time preceding each event on the left-hand side of each page;
- ♦ The team member's signature and the date must be placed at the bottom of every page;



- ♦ Notebooks that are relinquished from one team member to another during the day's activities will be signed over from one team member to the other. The time the notebook was relinquished must be noted and signed by one team member relinquishing the notebook and one team member accepting the notebook;
- ♦ An error made in the logbook will be crossed-out with a line and the correct information will be entered. All corrections will have to be initialed and dated. No 'white out' is permitted in the logbook.

### **5.6.3 Site Safety and Health Logbook**

A logbook will be maintained by the Site Health and Safety Officer (SHSO) to document all safety and health activities. The SHSO will be responsible for ensuring the following information is entered into the logbook:

- ♦ Daily health and safety meetings/briefings;
- ♦ Daily health and safety site inspections;
- ♦ Record of equipment used and daily inspection of field equipment;
- ♦ Weather, including general weather conditions, temperature, relative humidity, barometric pressure, wind, and direction, to be obtained from the National Weather Service or local sources. Major changes in weather conditions;
- ♦ Problems associated with field monitoring equipment;
- ♦ Medical problems with any field team member, including anyone taking special medications;
- ♦ Any visitors introduced at the site along with health and/or training records, as appropriate;
- ♦ Conversations with USACE personnel, TapanAm personnel, landowners, etc.; and
- ♦ Record extraordinary occurrences;

### **5.6.4 Daily Quality Control Report**

Accurate and completed field documents will provide records of field activities that are conducted in compliance with both the work plan and the project-specific performance objectives and standards of acceptability. A Daily Quality Control Report will be completed daily on the field site activities by Field Site Manager. He will also check on certain field documentation such as the COC daily as part of the data management activities. A Daily Quality Control Report form is located in Appendix J.

### **5.6.5 Field Forms**

Additional field information (e.g. sampling locations, QA samples collected for laboratory analysis, etc.) will be recorded on a Daily Field Sampling Report form (Appendix J). This form will facilitate the documentation of information pertinent to field activities. Other selected field forms such as Field Calibration Report forms and HTW Drilling Log forms (not sample collection forms or COCs) will be submitted to the TapanAm QA officer daily via facsimile by the Field Site Manager.

### **5.6.6 Photographic Log**

For each photograph taken during the project, the following items will be noted in the field logbook:

- ♦ Date and time;
- ♦ Photographer's name and signature;
- ♦ Site name;
- ♦ Brief description of the subject taken;
- ♦ Film roll number and sequential number of the photograph;
- ♦ Scale (e.g., ruler, rock hammer, drill rig).

Photographs taken to document sampling locations will include 2 or more permanent reference points within the photograph to facilitate relocating the sample location at a later date.

## **5.7 SAMPLE LABELING**

An adhesive sample label will be placed on each sample bottle or container that is to be shipped for laboratory analyses. The label will be preprinted and subsequently completed in the field by using a waterproof, indelible ink. Each label will be sealed with clear tape. The clear tape will not be placed over the container caps. Sample labels must contain sufficient information that can uniquely identify the sample even in the absence of other documentation. An example of the sample label is included in Appendix J. Labels should include at a minimum of:

- ♦ Project name;
- ♦ Sample ID number;
- ♦ Type of sample (composite, grab);

- ♦ Sample matrix (water, soil);
- ♦ Sampling date and time. For quality control samples such as matrix spike duplicates, the time of collection will be made the same for each related samples;
- ♦ Signature or initials of the individual(s) collecting the sample;
- ♦ Analytical Method requested;
- ♦ Preservation method employed.

A MicroSoft Excel spreadsheet will be developed and used to maintain and update a record, on a daily basis, of all samples collected and shipped for laboratory analyses. The spreadsheet will have columns of information regarding samples collection and shipment as follows:

- ♦ Project number;
- ♦ Sample ID number;
- ♦ Date and time of collection;
- ♦ Date and time of shipment;
- ♦ Fed-Ex number;
- ♦ Laboratory name;
- ♦ Date the lab received samples;
- ♦ Name of person inputting data.

## 5.8 SAMPLE PACKAGING

Environmental samples will be packaged for shipment as follows:

- ♦ Samples bottles or containers are adequately identified with sample labels. Refer to Section 5.7 for sample labeling;
- ♦ Labels are placed on the containers prior to collection;
- ♦ For all types of environmental samples tape will not be placed over container caps;
- ♦ Each sample container is wrapped with "bubble pack" and secured with clear tape;
- ♦ The containers are placed upright in the shipping container (i.e., cooler). More "bubble pack" or other packing material will be placed in between sample containers and the bottom as a liner at the discretion of the shipper;
- ♦ Shipping containers will have double-bagged ice among, and on top of samples, to maintain a temperature of 4.0 °C in the cooler;

- ♦ The COC form will be signed by the personnel who is relinquishing the samples. The form will then be placed in a plastic bag and sealed with custody seal and then taped onto the inner lid of the shipping container;
- ♦ A copy of the COC form will be kept in the project file. Upon receipt of the shipping container, the laboratory personnel will sign in the receiving block provided and a copy will be transmitted to TapanAm Project Manager with analytical results;
- ♦ The shipping containers will be secured with strapping tape and custody seals. The seal is applied so that the shipping containers cannot be opened without breaking the seal;
- ♦ The custody seal will be signed and dated by the Filed Site Manager who is in charge of the sample shipping. At least 2 custody seals are placed on the cooler, one on the front and one on the side. All openings will be taped shut to prevent potential leakage during transport.

## 5.9 SAMPLE SHIPPING

The carrier proposed for this project is the Fed-Ex. The Fed-Ex office nearest to the project is located in St. Louis, Missouri, approximately seven miles south of the project site. The telephone number for the FedEx is 1-800-463-3339.

Analytical Management Laboratories, Inc. (AM Lab) will analyze field and quality control samples such as field duplicates, rinsates, matrix spike and matrix spike duplicates. The QA replicates will be submitted to the USACE CQAB Laboratory in Omaha, Nebraska. Addresses and point of contact of the main laboratories are listed below:

### Primary Laboratory:

Mr. Vis Viswanathan, Ph.D.  
Analytical Management Laboratories, Inc.  
15130 South Keeler  
Olathe, Kansas 66062  
Phone: (913) 829-0101  
Fax: (913) 829-1181

### QA Laboratory:

Ms. Laura Percifield  
USACE CQAB Laboratory  
420 South 18<sup>th</sup> Street  
Omaha, NE 68102

Phone: (402) 444-4314

The following is the standard procedure for the shipping of the environmental samples to the analytical laboratory:

- ♦ The shipping of the environmental samples collected by the field team members will be done daily through Fed-Ex. Receipts are retained as part of the COC documentation;
- ♦ When the responsibility for custody of the sample changes, the new custodian will sign the record and note the date. The person receiving the shipment from the courier or carrier must sign as having received the package on the shipping paper;
- ♦ The Field Site Manager will notify the appropriate laboratory when samples collected by the field team members are ready for shipping;
- ♦ If prompt shipping and laboratory receipt of the samples cannot be guaranteed (i.e., Sunday arrival), the Field Site Manager will be responsible for proper storage and custody of the samples until transportation or shipment arrangements can be made.

## **5.10 RECORD AND DOCUMENTATION MAINTENANCE**

The Project Manager will be responsible for long-term maintenance of original copies of all records, documents, photographs, letters, computer records, and other materials generated for this PA/SI. Where the original document has been forwarded to a third party (shipping agents, laboratory, USACE, etc.) a copy will be maintained in the file in place of the original.

Documents and records will be maintained in dedicated locking file cabinets and will not be mixed with other documents or other projects. Should records be requested for review, copies will be made and originals will be returned to the files. Should originals be removed and replaced by copies, an "outcard" or "removed by" notice will be placed in the file with the copies.

# Sample Label

TapanAm Associates, Inc. Former St. Louis Ordnance Plant, St. Louis County, Missouri		<i>Sample Number</i>	
<i>Sample Type</i>	<i>Matrix</i>	<i>Preservative</i>	
<u><i>Container Information</i></u>			
<i>No.:</i>	<i>Size:</i>	<i>Type:</i>	
<i>Analysis:</i>			
<i>Method:</i>			
<i>Sample Date:</i> _____		<i>Sample Time:</i> _____	
<i>Sampler's Initials:</i> _____			

## 6.0 DECONTAMINATION

### 6.1 INTRODUCTION

This section describes methods and cleaning procedures of sampling equipment in order to prevent and reduce the risk of cross-contamination between samples. A proper decontamination procedure of field sampling equipment is necessary to meet the requirements of the QCP and the SSHP of the project. Unnecessary re-sampling work due to incomplete procedures during field equipment decontamination can also be avoided.

Alternative field decontamination procedures that are considered to be more effective, time and labor efficient must be documented on field variance forms and in the field logbooks.

### 6.2 TYPES OF EQUIPMENT

Table 6 shows the lists of field equipment and supplies for this project. In general, there are two types of field equipment that are involved in the cleaning procedures:

- ♦ non-sample contacting equipment – related equipment associated with the sampling effort, but does not have direct contact with the sample. For example, drilling bits, flow-through cell;
- ♦ sample-contacting equipment – equipment that comes in direct contact with the sample or a portion of the sample that will undergo chemical analyses or physical testing. For example, sampling spoons and metal bowls.

### 6.3 CLEANING MATERIALS

Below is a list of cleaning materials that will be used in the field sampling equipment decontamination:

- ♦ Non-phosphate detergent, i.e., Liquinox® will be used in decontamination solution;
- ♦ Potable water as wash solution or rinse water bath;
- ♦ Distilled/deionized water for final rinse of equipment;
- ♦ Paper towels to wipe off dirt and dry sampling tools;
- ♦ Water jugs for holding potable water;
- ♦ Brushes for abrasive decontamination;

- ♦ Galvanized tubs or plastic buckets for holding contaminated wash solutions for subsequent disposal;
- ♦ Spray bottles for potable and deionized water;

#### **6.4 FIELD CLEANING GENERAL REQUIREMENTS**

Procedures to reduce the risk of cross-contamination as listed below:

- ♦ A standard brand non-phosphate laboratory detergent such as Liquinox® will be used during field sampling equipment decontamination. The use of any other detergent must be justified and documented on a field change request form and the field logbooks. The detergent before and after use must be kept in a clean plastic, metal, or glass container at all times;
- ♦ The use of any untreated potable water supply is considered an unacceptable substitute for potable water. Potable water will be obtained from a municipal water treatment system;
- ♦ Potable water must be stored in clean tanks, sprayers, squeeze bottles or may be applied directly from a tap water source;
- ♦ Deionized water is defined as tap water that has been treated by passing through a standard deionizing resin column. The distilled/deionized water available from commercial vendors is acceptable for the purpose of sampling equipment decontamination. The deionized water will contain no heavy metals or other inorganic compounds. Deionized water must be stored in clean glass or plastic containers;
- ♦ During cleaning operations, the substitution of a higher grade water (e.g., deionized or organic-free water for tap water) is permitted and need not be noted as a variation;
- ♦ Clean equipment should be stored separately from the contaminated equipment;
- ♦ During equipment decontamination, the laboratory detergent and rinse water baths may be reused. However, new solutions must be prepared periodically, depending on the amount of equipment requiring decontamination;
- ♦ Isopropanol will be used, if necessary, as a solvent to clean field equipment covered with heavy grease. The isopropanol will be properly stored in its shipping container or in boldly labeled plastic spray bottles;
- ♦ The decontamination solution will be disposed of as IDW;
- ♦ Field personnel will have sufficient clean sampling equipment for effective and efficient sampling;



- ♦ Cover monitoring and sampling equipment with protective material such as plastic sheeting or aluminum foil to minimize cross-contamination during transport between sampling locations;
- ♦ Use disposable sampling equipment and disposable personal protective gloves/clothing when practical.

## **6.5 FIELD EQUIPMENT STORAGE**

All field equipment will be stored in a contaminant-free environment after being decontaminated. Field equipment will not be stored and transported near fuel sources. Equipment will be moved upwind of the decontamination area and allowed to air dry. The decontaminated equipment will then be placed in a plastic bag or wrapped in aluminum foil.

## **6.6 HEALTH AND SAFETY PROCEDURES DURING DECONTAMINATION OPERATIONS**

All field personnel who are directly or partially in contact with the contaminated sampling equipment will properly exercise the health and safety procedures. Detailed health and safety procedures are described in the SSHP of this project. At a minimum, the following precautions shall be taken in the decontamination area during cleaning operations:

- ♦ Safety glasses with side shields or goggles and nitrile or latex inner gloves will be worn during all cleaning operations. When steam cleaning equipment, workers must also wear saranex coveralls and rubber steel-toed boots;
- ♦ Eating, smoking, drinking, chewing, or any hand-to-mouth contact shall not be permitted during cleaning operations;
- ♦ Certain hazardous substances may be incompatible with decontamination solution or solvent. The chemical incompatibility may hence cause the production of heat, explosion or toxic products. Thus, the decontamination solutions or solvents used should be determined for their compatibility before use;
- ♦ Any substance that permeates, degrades, or damages personal protective equipment should not be used. Decontamination methods that may potentially cause direct health hazards should be immediately reported and modified.

## 6.7 QUALITY CONTROL FOR DECONTAMINATION PROCEDURES

This section establishes guidelines for specific QC procedures to monitor the effectiveness of the sampling equipment cleaning procedures. The effectiveness of the equipment cleaning procedures shall be evaluated by employing the equipment rinsate blank. All QC procedures will be recorded in the field logbook.

### 6.7.1 Equipment Rinsate Blank

This QC approach will provide information on the effectiveness of the decontamination procedures employed in the soil, sediment, surface and groundwater sample collections. An equipment rinsate blank consists of a sample of analyte-free, deionized/distilled water, which is passed over decontaminated, rinse-cleaned field equipment (i.e., submersible pumps, and metal spoons), and collected in a clean laboratory sample container. The rinsate samples will be collected and submitted for laboratory analyses in accordance with the sampling schedule presented in Table 5.

The equipment rinsate blank will be collected for selected pieces of equipment in 6 different matrices (i.e., direct-push groundwater, monitoring well groundwater, surface water, sediment, surface and subsurface soil) as shown in Table 5. The table also shows the rate of equipment rinsate blank collection from each matrix. The equipment rinsate blank will be collected after the equipment has been cleaned (i.e., between sampling points). The following procedures will be used to collect equipment rinsate blanks from cleaned field equipment:

- ♦ Follow Table 5 for the determination of matrix and when to collect the equipment rinsate blank;
- ♦ Follow the equipment cleaning procedures listed in Section 6.11. If the rinsate blank is collected from a submersible pump, be sure to rinse the sample contact portion of the disassembled pump with deionized water;
- ♦ Fill laboratory-supplied containers with the analyte-free, deionized/distilled water rinsate;
- ♦ Follow Section 5.0 for the proper equipment rinsate blank nomenclature, labeling, and documentation.

## **6.8 DATA DOCUMENTATION**

All cleaning procedures of the equipment and QC samples collection will be properly documented in the field logbooks. Any deviation of the cleaning protocol must be documented.

## **6.9 DECONTAMINATION GENERAL REQUIREMENTS**

All personnel, drilling equipment, and sampling equipment must be decontaminated before entering and leaving the contaminated area of a site, between each and every sampling location. For each boring, the drilling equipment will be checked for possible contamination sources such as oil and grease leakage. Any problem regarding drilling equipment should be repaired prior to mobilizing to the project site. All sampling equipment and monitoring equipment will be checked for their proper functions and calibration accuracy. The sampling equipment will be cleaned prior to mobilizing to the project site.

## **6.10 CLEANING REUSEABLE SAMPLE CONTACTING EQUIPMENT**

It is most desirable to use disposable sampling equipment to reduce the potential of cross-contamination in the field. However, for sample contacting equipment that is reusable, such as plastic and metal sampling equipment, the following procedures outlined in this section will be followed:

### **6.10.1 Sampling Equipment for Organic and Metal Analyses**

The reusable sampling equipment for collecting samples for VOC and metals analyses (i.e., Teflon<sup>TM</sup>, stainless steel bowls, soil sampling trowels) will be cleaned between sampling locations as listed below:

- ♦ Wash and scrub equipment thoroughly with Liquinox® and potable water with a brush to remove any particulate matter or surface film;
- ♦ Rinse equipment thoroughly with potable water;
- ♦ Rinse equipment thoroughly with deionized water;
- ♦ Allow equipment to air dry as much as possible. It is important to have sufficient clean sampling equipment staged in the field to have time to air drying equipment while pursuing the next sampling task;

### **6.10.2 Disposable Sampling Equipment**

Disposable tubing and bailers will be used in direct-push and groundwater monitoring well sample collection. A disposable bailer will be used for sampling water from direct-push piezometers. The tubing will also be dedicated to a specific well during its development and the sampling of the same well. Disposable equipment will be discarded at the completion of the well development. New tubing or a new bailer will be used for each discrete sampling event.

Bonded poly tubing will be used for non-well development, and Teflon-lined bonded poly tubing will be used for groundwater sampling. Tubing used for the developing and sampling pump will be discarded in between samples. The following procedures apply to dedicated disposable tubing and bailers each time new ones are used:

- ♦ Remove equipment from manufacturer packaging;
- ♦ Rinse the equipment with distilled/deionized water if packaging is compromised.

### **6.10.3 Sampling Equipment Contaminated with Adhesive Materials**

In cases where reusable measuring equipment is used and contaminated with highly adhesive materials, additional decontamination procedures using solvents may be required. Additional decontamination steps will have to be implemented on cleaning procedures in Section 6.10.1. The following procedures outline the cleaning steps for sampling equipment contaminated with adhesive materials:

- ♦ If sampling equipment used for sample collections contains oil, grease, or other lubricants which cannot be easily removed, it may be necessary to rinse the equipment several times with isopropanol to remove the adhesive materials;
- ♦ Once the resistant material is completely removed from the equipment, wash and scrub the equipment thoroughly with Liquinox®, potable water, and a brush to remove any particulate matter or surface film;
- ♦ If there is still remnant oil, grease or other materials covering the equipment, repeat the first 2 steps until the material is successfully removed;
- ♦ Rinse equipment thoroughly with tap water;
- ♦ Rinse equipment thoroughly with deionized water;

- ♦ Allow equipment to air dry as much as possible. It is important to have sufficient clean sampling equipment staged in the field to have time to air dry equipment while pursuing the next sampling task;
- ♦ Wrap equipment in one layer of aluminum foil. Roll edges of foil into a "tab" to allow for easy removal.

## **6.11 CLEANING SPECIFIC SAMPLING EQUIPMENT**

Like other sampling equipment, specific flow through cells and pumps and large equipment (drilling rigs) will be cleaned prior to use and between sample locations.

### **6.11.1 Water-Level Indicators**

Water-level indicators are considered as sample contacting equipment as they may be in contact with potential contaminated groundwater. Personnel will clean water level indicators in accordance with these procedures between each well. The cleaning procedures apply to cleaning water level indicators and other sounding equipment will be the same as sampling equipment used for organic and metal analyses, see Section 6.10.1.

### **6.11.2 Well Riser and Well Screen**

The well riser and well screen are used in the installation of monitoring wells. Only if the factory packaging is compromised, the well riser and screen are required to be steam-cleaned prior to installation. There is no need to decontaminate well risers and screens if there are wrapped and stored away from fuel sources. The cleaning procedure is outlined below:

- ♦ Steam-clean the inner and outer surfaces of equipment with high-pressure hot water.
- ♦ Rinse risers and screens thoroughly with potable water;
- ♦ Rinse risers and screens thoroughly with deionized water; and
- ♦ Allow risers and screens to air dry as much as possible.

### **6.11.3 Bladder Pumps**

Decontamination of pumps will be conducted between each well and each pumping event. Pumps that are coming in contact with potentially contaminated groundwater are considered

sample-contacting equipment. Thus, decontamination procedures described in the manufacturer's literature should be followed as much as there are practicable. The following provides generalized decontamination procedures for bladder pumps:

- ♦ Pump approximately 1 gallon of soapy water through the pump to flush out any residual purge water;
- ♦ Brush and scrub the exterior of the contaminated electrical supply/ control cables and air hose. Spray hot, soapy water on them and wash out the soap with potable water. Finally, rinse them with distilled/deionized water and recoil onto the spool;
- ♦ Pump approximately 1 gallon of potable water through the pump to flush out soapy water. Disassemble the bladder pump by unscrewing the screened portion of the pump casing, and remove the bladder. Rinse the outside of the bladder and the inside of the pump casing with hot, soapy water. Rinse them with tap water and then distilled/deionized water;
- ♦ Reassemble the pump and pump approximately 1 gallon of deionized water through the pump to flush out the tap water;
- ♦ Place the equipment in a plastic bag to prevent contamination during storage or transport.

#### **6.11.4 Drilling Equipment**

A decontamination pad will be constructed on-site prior to beginning decontamination procedures on any drilling rig or drilling equipment. Drilling equipment will be decontaminated prior to the commencement of drilling activities.

The hollow stem auger drilling equipment is considered non-sample contacting equipment. The drilling subcontractor will be responsible for conducting proper decontamination of drilling equipment. Drilling equipment in contact with the subsurface will be placed on racks or saw horses at least two feet above the floor of the decontamination pad and steam-cleaned with high pressure hot water. Persistent particulate matter or surface films will be removed with potable water and Liquinox®, scrubbing, and a potable water rinse. Drill rods that are hollow or have holes that transmit water will be cleaned on the inside with vigorous brushing, detergent, and steam cleaning, followed by a potable water rinse.

After completion of decontamination, the equipment will be removed from the decontamination pad and covered with clean new plastic until the equipment is used again.

Water used during the decontamination process will be pumped into 55-gallon drums and stored on-site until proper disposal procedures can be conducted.

#### **6.11.5 Flow-Through Cell**

The water quality meter and flow-through cell are non-sample contacting equipment. The following are procedures to clean the flow-through cell:

- ♦ The YSI 6820 Series Data Sonde will be removed from the flow-through cell prior to decontamination;
- ♦ The flow-through cell will be disconnected from the associated sample tubing and submerged in soapy water;
- ♦ The samplers will use their hands to cap the ends of the cell. Note that samplers must wear disposable latex gloves during decontamination;
- ♦ The soapy water will be agitated in the cell;
- ♦ Samplers will use their fingers to dislodge any remaining sediment (stiff brushes should not be used in the flow-through cell to prevent scratches). This procedure will be repeated with tap water;
- ♦ The flow-through cell will be rinsed thoroughly with deionized water, and stored in a 10 gallon-sized plastic bag.

#### **6.11.6 Field Analytical Equipment and Other Field Instruments**

Decontamination of field analytical equipment and other field instruments will follow the respective manufacturer's recommendations.

The exterior of sealed, watertight equipment will be washed with a Liquinox® solution and rinsed with potable water before storage. The interior of such equipment may be wiped with a paper towel if necessary. Conductivity probes, pH meter probes, DO meter probes, etc., will be rinsed with deionized water before storage.

### **6.12 DECONTAMINATION FLUID CONTAINMENT AND DISPOSAL**

All field sampling equipment will be decontaminated at a designated area. The decontamination area shall be downgradient and downwind (prevailing wind direction) of the clean equipment

drying and storage area. The decontamination area will be lined with heavy-duty plastic sheeting for the containment of wash water and waste. Alternatively, a ground level pad may be set up which consists of a frame and impermeable liners. The decontamination area will be designed such that wash water and waste fluids will be properly contained and easily transferred to drums for disposal. All decontamination liquids will be containerized in 55-gallon DOT-approved drums. Sediment will be collected in separate drums.

Drums that contain contaminated wash-water and waste fluids will be labeled and sealed according to the procedures specified in the IDW Section 4.8.5, and stored in a designated area. Drum labeling will indicate the contents and the date of generation.



## **7.0 CORRECTIVE ACTIONS**

This section describes corrective action procedures to be followed for any fieldwork discrepancy during the course of the PA/SI. The Project Manager, Field Site Manager, field team members, and/or subcontractors are responsible for ensuring the field procedures are followed as specified and meet the prescribed acceptance criteria. Once corrective actions are identified by the respective personnel, resolution to each discrepancy will be implemented as approved by the USACE Project Manager.

In the case of field data collection and measurement, if corrective actions taken are still not meeting the quality control criteria, new resolutions will be discussed to determine the best possible corrective action.

### **7.1 CORRECTIVE ACTION DOCUMENTATION**

Any field discrepancies from procedures outlined in the SOP, FSP, and/or SSHP will be documented on a Variance Form and Variance Log and will be noted in the field logbooks. The implementation corresponding to the corrective actions taken will also be documented. This implementation includes any changes or modification of project procedures. The Variance Form and Variance Log are included in Appendix J.

### **7.2 CORRECTIVE ACTION PERSONNEL**

For any corrective actions taken, the field team members will be responsible for the implementation of the FSP procedures.

The Field Site Manager will approve and document any minor field changes in the logbook. He/She will also document any minor changes in the Variance Form in the field. A verbal approval from the USACE Project Manager will be obtained prior to making the change and will be noted in the field logbook. A minor field change is one that does not affect the objectives of the FSP.

The TapanAm QC auditor will perform an independent oversight of the field project. Any deviation of the FSP procedures will be reported to the QC Manager. Major field changes that will affect the field sampling objective and/or schedule will be reported to the TapanAm Project

Manager. A verbal notification, followed by written notification of major field changes will be submitted to the USACE Project Manager. The TapanAm Project Manager and the USACE Project Manager will approve all Variance Forms prior to the implementation of any corrective actions.

### **7.3 FIELD INSTRUMENTAL CORRECTIVE ACTION**

It is the responsibility of the Field Site Manager to show all field team members the standard calibration and operation of all field instruments used. Any instrumental malfunctions will be immediately reported to the Field Site Manager and the Project Manager. The Project Manager will be responsible for arranging repair or replacement of the instrument. Improper calibration of field instruments, as well as the corrective action taken will be documented in the field logbook. Table 7 shows a summary of the corrective actions that may be taken if instrumental readings are out of the standard range.

### **7.4 FIELD SAMPLE PRESERVATION CORRECTIVE ACTION**

The Field Site Manager will supervise the field team members on field sample preservation procedures. Sample bottles or containers will be inspected by the field team members for defects prior to sample collection. Sample bottles or containers that have leakage or insufficient amount of preservative will be discarded and new sample containers will be used. The field sample preservation circumstances will be documented in the field logbook and on the Variance Form.

### **7.5 LABORATORY CORRECTIVE ACTION**

The laboratory corrective action is described in Section 10.0 of the QAPP.

### **7.6 VARIANCE FORMS**

Problems related to the samples upon receipt at the laboratory will be addressed by the Field Site Manager or the Project Manager. The Field Site Manager is responsible for checking the sample labels for mislabeling. In this circumstance, the proper correction of labeling will be made immediately prior to the documentation of the COC. If sample bottles or containers are found broken or missing from the cooler, the laboratory personnel will notify the Project Manager. An

arrangement to resample will be made. Proper documentation of the circumstances surrounding the variance will be attached to the original chain-of-custody form to document the corrective action.

During laboratory quality control testing of field samples such as surrogates, matrix spikes, and relative percent differences, incidence of laboratory errors will be reported by laboratory personnel to the Project Manager and the USACE Project Manager. An investigation will be performed by the laboratory personnel. A laboratory quality control confirmation report will be documented and submitted to the Project Manager. The Project Manager and the USACE Project Manager will decide if corrective action of resampling is required. Proper documentation of the Variance Form will be attached to the original report to document the corrective action.

## **8.0 SURVEYING**

### **8.1 SURVEYING OF SAMPLE LOCATION**

Surface soil, subsurface soil, and sediment sampling locations, as well as the direct-push boring locations will be surveyed using a GPS system. The sample locations surveyed will be field marked with survey flags after sample collection. The sample location survey points for the surface soil, subsurface soil, sediment, direct-push groundwater, and groundwater monitoring wells, will be transferred to the site map.

A survey marker shall be affixed to the concrete pad of each groundwater monitoring well. Both the survey marker and the top of casing elevations for each well will be surveyed. The survey marker will be composed of brass, bronze, or aluminum alloy. The following information will be included on the survey marker: well identification number; well location coordinates (measured to the nearest tenth (0.1) of a foot); and top of casing elevations (measured to the nearest hundredth (0.01) of a foot).

Coordinates will be referenced to the Missouri State Plane Coordinate System. Elevations will be referenced to the U.S. Geological Survey National Geodetic Vertical Datum of 1929, or the North American Vertical Datum of 1983. The local vertical datum will be used as an alternate, if the National Geodetic Vertical Datum of 1929 or the North American Vertical Datum of 1983 are not available.

To provide sufficient survey control, benchmarks should be established as determined by site conditions. The surveyor will record all field survey data in a field logbook including structures, roads, fences, power lines, and other pertinent features.

### **8.2 DOCUMENTATION**

The locations of all installed benchmarks and monuments will be appropriately documented on a base map to indicate their relative locations. Benchmarks will be described with respect to their construction and location on map, in addition to their grid coordinates.

### **8.3 SURVEYING OF DIRECT-PUSH BOREHOLES**

Horizontal locations and ground surface elevations for direct-push boreholes, indicated on Figure 2. Horizontal locations will be measured to the nearest foot, and ground surface elevations will be measured to 0.1 foot. The sample locations surveyed will be field marked with labeled survey flags after sample collection. Survey flags will indicate boring number, grid coordinates and ground-surface elevation. Elevations will be marked on a wooden surveying stake placed next to the temporary piezometer.

After post-processing, coordinates will be referenced to the Missouri State Plane Coordinate System with 1 centimeter (cm) horizontal control and 2 cm vertical control. The coordinates from the direct-push groundwater sample locations will be transferred to the site map.

### **8.4 SURVEYING OF MONITORING WELLS**

In general, horizontal location, well riser elevation, and ground surface elevation criteria for monitoring wells are similar to those of direct-push borehole logging. However, the surveyor will measure and mark the elevation of the top of the riser to the nearest 0.01 of a foot since this reference point will be used to measure groundwater elevations. Top of casing elevation will be recorded. The well location, ground surface elevation, and top of casing will be surveyed after well installation

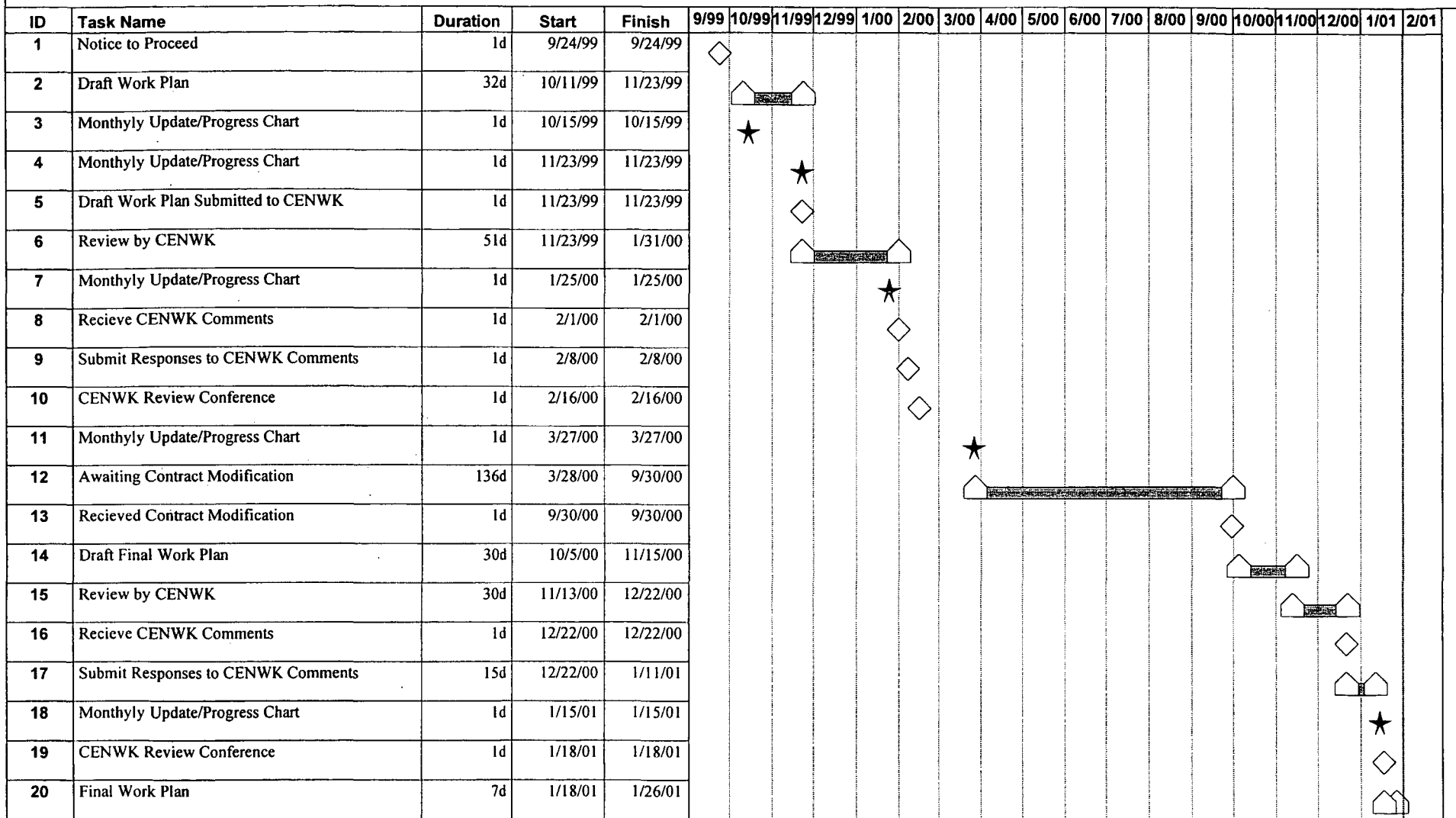
### **8.5 SURVEYING OF SURFACE WATER, SOIL, AND SEDIMENT SAMPLE LOCATIONS**

Surface water, soil, and sediment sample locations will be surveyed using a GPS system. A location stake with the sample number and coordinates may be used as a reference point for measuring the surface water elevation in the sewers and tunnel.

## 9.0 PROJECT SCHEDULE

The proposed schedule for preparation of the Work Plan documents, field implementation, and completion of the final report is presented in the following pages.

**Phase I Project Schedule for the Former St. Louis Ordnance Plant PA/SI, St. Louis, Missouri**  
**Contract No. DACW41-98-D-9010 DO No. 002**



Project : St. Louis Ordnance Plant  
1/31/01

Task



Milestone
















Progress



Monthly Update ★

# Phase II Project Schedule for the Former St. Louis Ordnance Plant PA/SI, St. Louis, Missouri

Contract No. DACW41-98-D-9010 DO No. 002

ID	Task Name	Duration	Start	Finish	1/01	2/01	3/01	4/01	5/01
1	Pre-field Investigation Meeting (Laboratory)	1d	1/31/01	1/31/01					
2	Powder Well Sampling	5d	2/12/01	2/16/01					
3	Monthly Update/Progress Chart	1d	2/15/01	2/15/01		★			
4	Surface Soil Sampling	5d	2/19/01	2/23/01					
5	Sediment Samples/Video Sewer Inspection	5d	2/19/01	2/23/01					
6	GPS Sample Location Surveying	10d	2/19/01	3/2/01					
7	Geoprobe Groundwater Investigation	5d	2/26/01	3/2/01					
8	Data Evaluation	4d	3/7/01	3/12/01					
9	Post-field Investigation Meeting	1d	3/12/01	3/12/01					
10	Monitoring Well Installation	4d	3/13/01	3/16/01					
11	Monitoring Well Development	3d	3/15/01	3/19/01					
12	Monthly Update/Progress Chart	1d	3/15/01	3/15/01			★		
13	Monitoring Well Sampling	4d	4/3/01	4/6/01					
14	Monthly Update/Progress Chart	1d	4/15/01	4/15/01				★	
15	Data Evaluation/Validation (Groundwater)	5d	4/23/01	4/27/01					
16	IDW Management/Disposal	10d	4/23/01	5/4/01					

Project: St. Louis Ordnance Plant  
Date: 1/31/01

Task



Milestone



Progress












Monthly Update





**Phase III Project Schedule for the Former St. Louis Ordnance Plant PA/SI, St. Louis, Missouri**  
**Contract No. DACW41-98-D-9010 DO No. 002**

ID	Task Name	Duration	Start	Finish	3/01	4/01	5/01	6/01
1	Phase III Startup	1d	4/9/01	4/9/01				
2	Quality Control Summary Report	10d	4/9/01	4/20/01				
3	Draft Report	20d	4/9/01	5/4/01				
4	Monthly Update/Progress Chart	1d	4/16/01	4/16/01				
5	Review by CENWK	7d	5/4/01	5/14/01				
6	Submit Draft Final Report	4d	5/15/01	5/18/01				
7	CENWK Review Conference	1d	5/25/01	5/25/01				
8	Submit Final Report	5d	5/28/01	6/1/01				
9	IDW Disposal	2d	6/4/01	6/5/01				

Project: St. Louis Ordnance Plant  
Date: 1/31/01

Task



Progress



Milestone



Monthly Update



## 10.0 REFERENCES

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U.S. Geological Survey (1954) Clayton Quadrangle Missouri, 7.5 Minute Series (topographic) map, photo-revised 1993.



## LIST OF TABLES

Table 1

Generalized stratigraphic column for St. Louis,  
St. Charles, and Jefferson Counties, Missouri

Aquifers most favorable as water sources are shaded

Aquifers most favorable as water sources are shaded										
System	Series	Group	Formation	Aquifer group	Thickness (feet)	Dominant lithology	Water-bearing character			
Quaternary	Holocene		Alluvium		0-150	Sand, gravel, silt, and clay.	Some wells yield more than 2,000 gpm.			
	Pleistocene		Loess Glacial till		0-110 0-55	Silt Pebbly clay and silt.	Essentially not water yielding			
Pennsylvanian	Missourian	Pleasanton	Undifferentiated		0-75	Shales, siltstones, "dirty" sandstones, coal beds and thin limestone beds.	Generally yields very small quantities of water to wells. Yields range from 0-10 gpm.			
	Desmoinesian	Marathon	Undifferentiated		0-90					
		Cherokee	Undifferentiated		0-200					
	Atokan		Undifferentiated							
Mississippian	Meramecian		Sta. Genevieve Formation	1	0-160	Argillaceous to arenaceous limestone.	Yields small to moderate quantities of water to wells. Yields range from 5 to 50 gpm. Higher yields are reported for this interval locally.			
			St. Louis Limestone		0-180					
			Salem Formation		0-180					
			Warsaw Formation		0-110					
	Osagean	Burlington-Kaskaskia Limestone	0-240		Cherty limestone					
		Pera Glen Formation	0-105		Red limestone and shale					
Devonian	Upper	Sulphur Springs	Undifferentiated		0-122	Limestone, dolomitic limestone, shale, and siltstone.				
			Bushberg Sandstone		0-60			Limestone and sandstone.		
			Glen Park Limestone		0-50			Pisgah, carbonaceous shale.		
Silurian			Grassy Creek Shale							
			Undifferentiated		0-200	Cherty limestone.				
Ordovician			Maquoketa Shale		0-163	Silty, calcareous or dolomitic shale.	Probably constitutes a confining influence on water movement.			
	Cincinnatian		Cape Limestone		0-5	Argillaceous limestones.	Yields small to moderate quantities of water to wells. Yields range from 3 to 50 gpm.			
			Kimmswick Formation		0-145	Massive limestone				
	Champlainian		Decorah Formation	2	0-50	Shale with interbedded limestone.	Decorah Formation probably acts as a confining bed locally.			
			Plattin Formation		0-240	Finely crystalline limestone.				
			Rock Levee Formation		0-93	Dolomite and limestone, some shale.				
			Joachim Dolomite		0-135	Primarily argillaceous dolomite.				
					St. Peter Sandstone	3		0-160	Silty sandstone, cherty limestone grading upward into quartzose sandstone.	Yields moderate quantities of water to wells. Yields range from 10-140 gpm.
			Everson Formation		0-130					
	Canadian		Powell Dolomite	4	0-150	Sandy and cherty dolomites and sandstone.	Yields small to large quantities of water to wells. Yields range from 10 to 300 gpm. Upper part of aquifer group yields only small amounts of water to wells.			
			Ocker Dolomite		0-320					
			Jefferson City Dolomite		0-225					
			Roubidoux Formation		0-177					
Gasconade Dolomite			0-280							
Gunter Sandstone Member										
Cambrian	Upper	Elvins	Emmence Dolomite	5	0-172	Cherty dolomites, siltstones, sandstone, and shale.	Yields moderate to large quantities of water to wells. Yields range from 10 to 400 gpm.			
			Robert Dolomite		0-325					
			Derby-Dorwin Dolomite		0-163					
			Davis Formation		0-150					
			Bonneterre Formation		245-385					
			Lawotte Sandstone		235+					
Precambrian						Igneous and metamorphic rocks.	Does not yield water to wells in this area.			

1/ Basal part may be of Pleistocene age.

NOTE: Stratigraphic nomenclature may not necessarily be that of the U.S. Geological Survey.

Table 2. Summary of Key Personnel and Contact Information

<b>Role</b>	<b>Key Personnel/ Phone Number</b>	<b>Organization</b>	<b>Responsibilities</b>
Project Manager	<b>Danniel Mroz, P.E.</b> (816) 983-3368	<b>USACE</b> Kansas City	Project management
Technical Manager	<b>Kurt Baer, P.E.</b> (816) 983-3922	<b>USACE</b> Kansas City	Technical management
QA Laboratory Supervisor	<b>Laura Percifield</b> (402) 444-4313	<b>USACE CQAB Lab</b> Omaha	Sample management
Project Manager	<b>Siva Sivalingam, Ph.D.</b> (816) 941-6100	<b>TapanAm</b>	Project management
Site Manager & SHSO	<b>Mike Mckinley, P.G.</b> (816) 941-6100	<b>TapanAm</b>	Responsible to the project health and safety program
Laboratory Services	<b>Vis Viswanathan, Ph.D.</b> (913) 829-0101	<b>AM Lab</b>	Management and adherence to SOP and QAPP
Direct-Push Investigation	<b>Cecil Harris</b> (618) 539-3180	<b>Harriss Drilling Services, Inc.</b>	Direct-push investigations
Well Drilling	<b>Cecil Harris</b> (618) 539-3180	<b>Harriss Drilling Services, Inc.</b>	Hollow stem drilling, well installation, and development
IDW Handling	<b>Rick Orelt</b> (316) 681-3382	<b>Environmental Operations, Inc.</b>	IDW removal and disposal
Powder Well Sampling	<b>Stephen Voland</b> (423) 988-6067	<b>EOD Technology, Inc.</b>	Powder well neutralization and safe sampling of powder well sediments
Sewer Survey	<b>Steve Hontz</b> (816) 241-2891	<b>Ace Pipe Cleaning, Inc</b>	Sewer survey using closed circuit television inspection
Land Surveying	<b>David Sherrill</b> (314) 421-2615	<b>Sherrill Associates, Inc</b>	Monitoring well surveys
QA/QC/Audits/ Review	<b>Michael Katzman, P.G.</b> (913) 451-1988	<b>Katzman Consulting</b>	Field auditing, reviewing QCP and FSP reports
Industrial Hygiene Services	<b>Ralph Keller, C.I.H.</b> (816) 363-1409	<b>RMK Consultants</b>	Health and safety Plan review/supervision
Groundwater Quality Parameter (YSI 6820)	<b>David Casenhiser</b> (937) 767-7241	<b>YSI Incorporated</b>	The YSI 6820 measures pH, turbidity, conductivity, ORP, temperature, and DO
Field Screen of Turbidity (DRT 15CE)	<b>Technical Support</b> 1-800-789-2116	<b>HF Scientific</b>	The HF turbidimeter measures turbidity

Table 3. Analytical Methods for Sample Analysis

PARAMETER	SW METHOD FOR SOIL/WATER
VOC	8260B
TAL Metals (all except for):	6010B
- Arsenic	7060A
- Lead	7421
- Mercury	7471(S)/7470(W)
- Selenium	7740
- Thallium	7841
Explosives	8330B

Note:

All analytical methods derived from *Test Methods for Evaluation of Solid Waste*, SW-846, 3<sup>rd</sup> Ed.

Table 4. Summary of Sample Container Specifications, Preservatives, Sample Volumes, and Holding Times

Analyte	Minimum Sample Volume	Container	Preservative	Holding Time (VTS) <sup>1</sup>
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**Groundwater/Surface water:**

VOCs	40 mL	3-40 mL glass vial	HCl, pH < 2 Cool 4 + 2°C	14 days
TAL Metals	100 mL	1000 mL HDPE	HNO <sub>3</sub> , pH < 2 Cool 4 + 2°C	6 months (except. Hg) 28 days (Hg)
Explosive Residues	1000 mL	1000 mL dark amber glass	Cool 4 + 2°C	7 days to extract 30 days to analyze

**Soil/Sediment:**

VOCs	5 mg plugs 3 X 40 ml	EasyDraw Syringe™	Cool 4 +/- 2°C Sodium Bisulfate	48 hours
TAL Metals	5 grams (exc. Hg) 1 gram (Hg)	4 oz. Wide-mouth clear jar	Cool 4 +/- 2°C	6 months (except Hg) 28 days (Hg)
Explosives Residues	5 grams	4 oz. Wide-mouth clear jar	Cool 4 +/- 2°C	14 days to extract 40 days to analyze

**Subsurface Soil:**

VOCs	5 mg plugs 3 X 40 ml	EasyDraw Syringe™	Cool 4 +/- 2°C Sodium Bisulfate	48 hours
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## Notes:

Additional sample volume is required for matrix quality control.

<sup>1</sup>VTS - Verified Time of Sampling



Table 5. Summary of Analytical Sample, QC Samples, and Analytical Method

Matrix	Chemical Compounds	Analytical Methods SW 846	Primary Sample	Field QC Replicate (10%)	Field QA Replicate (10%)	Matrix Spike	Matrix Spike Duplicate	Trip Blank	Rinse Blank
Surface Soil	Explosives	8330B	46	4	4	2	2	2	4
	Metals	6010B/ 7000 Series	46	4	4	2	2	2	4
	VOCs	8260B	14	1	1	2	2	2	4
Subsurface Soil	Explosives	8330B	5	1	1	1	1	1	1
	Metals	6010B/ 7000 Series	5	1	1	1	1	1	1
	VOCs	8260B	5	1	1	1	1	1	1
Tunnel Sediment	Explosives	8330B	6	0	0	0	0	0	0
	Metals	6010B/ 7000 Series	6	0	0	0	0	0	0
Sewer Sediment	Explosives	8330B	7	1	1	1	1	1	1
	Metals	6010B/ 7000 Series	7	1	1	1	1	1	1
	VOCs	8260B	7	1	1	1	1	1	1
Powder Well Sediment	Explosives	8330B	22	2	2	2	2	0	2
	Metals	6010B/ 7000 Series	22	2	2	2	2	0	2
Surface Water	Explosives	8330B	9	1	1	1	1	1	1
	Metals	6010B/ 7000 Series	9	1	1	1	1	1	1
	VOCs	8260B	3	1	1	1	1	1	1
Direct-Push Groundwater	Explosives	8330B	16	1	1	1	1	1	2
	Metals	6010B/ 7000 Series	16	1	1	1	1	1	2
	VOCs	8260B	16	1	1	1	1	1	2
Groundwater Monitoring Well	Explosives	8330B	6	1	1	1	1	1	1
	Metals	6010B/ 7000 Series	6	1	1	1	1	1	1
	VOCs	8260B	6	1	1	1	1	1	1

Table 5. Summary of Analytical Sample, QC Samples, and Analytical Method (contd.)

Matrix	Chemical Compounds	Analytical Methods SW 846	Primary Sample	Field QC Replicate (10%)	Field QA Replicate (10%)	Matrix Spike	Matrix Spike Duplicate	Trip Blank	Rinse Blank
IDW Soil	Explosives	8330B	2	0	0	0	0	1	0
	Metals	6010B/ 7000 Series	2	0	0	0	0	1	0
	VOCs	8260B	3	0	0	0	0	1	0
IDW Water	Explosives	8330B	3	0	0	0	0	0	0
	Metals	6010B/ 7000 Series	3	0	0	0	0	0	0
	VOCs	8260B	3	0	0	0	0	0	0
Drilling Water	Metals	6010B/ 7000 Series	1	0	0	0	0	0	0
	VOCs	8260B	1	0	0	0	0	0	0

Table 6. List of Field Equipment and Other Materials

I Administrative

- ♦ Contract Specifications
- ♦ Contract Plans
- ♦ Contract Quality Control Plan
- ♦ Sampling and Analysis Plan (SAP)
- ♦ Site Safety and Health Plan (SSHP)
- ♦ Soil Erosion and Sediment Control Plan
- ♦ Demolition Plan
- ♦ Excavation and Backfilling Plan
- ♦ Waste Disposal Plan
- ♦ Field Forms (DCQCR, DCR, DFSR, etc.)
- ♦ Phone Log Form
- ♦ Field Logbooks
- ♦ Munsel Color Book
- ♦ Quality Control Sample Tables from SAP
- ♦ Chain of Custody Forms (COC)
- ♦ Address, telephone number, and Point of Contact (POC) for Primary Laboratory
- ♦ Address, telephone number, and POC for QA Laboratory
- ♦ Field SOPs
- ♦ Base Maps for Documenting Sample Locations
- ♦ NIOSH Pocket Guide
- ♦ Hazardous Waste Manifest Forms and Instructions
- ♦ Checklists
- ♦ Field Instrument Operating Manuals
- ♦ Field Instrument Repair Manuals
- ♦ Sample Shipping Documents (FedEx air bills, etc.)
- ♦ Communication Equipment (cell phones)

II Field Instrumentation (as required)

- ♦ YSI 6820 Series Data Sonde (measures pH, temperature, DO, turbidity, conductivity, ORP)
- ♦ PID Field Screening Instrument, MiniRAE
- ♦ DRT- 15CE Portable Turbidimeter
- ♦ Calibration gases
- ♦ Calibration standards
- ♦ Water level indicator

Table 6. List of Field Equipment and Other Materials (cont.)

### III Sampling Supplies

- ♦ Decontamination Materials (Alconox, Liquinox, rinse water [DI], solvents)
- ♦ Brush
- ♦ Squirt Bottles
- ♦ Stainless Steel Mixing Bowls
- ♦ Stainless Steel Sampling Bowls
- ♦ Dilute Hydrochloric Acid
- ♦ Dilute Nitric Acid
- ♦ Paper Towels
- ♦ Sample Containers with Caps
- ♦ Water Sample vials
- ♦ Sample Labels
- ♦ Sample Preservatives (if bottles are not pre-preserved)
- ♦ Bottle Custody Seals
- ♦ Cooler Custody Seals
- ♦ Sample Shipping Coolers
- ♦ Plastic (Ziplog®) Bags (gallon, quart, and pint sizes)
- ♦ Ice Packs (normal as well as blue ice)
- ♦ Hand Augers
- ♦ Disposable Bailers
- ♦ Steel Measuring Tapes
- ♦ Measuring Wheel
- ♦ Strapping Tapes
- ♦ Clear Tapes
- ♦ Trash Bags
- ♦ Bubble Packs
- ♦ Disposable Hand Gloves
- ♦ Clip Boards
- ♦ First Aid Kits
- ♦ 55-gallon Drums
- ♦ Plastic sheet
- ♦ Caution tape
- ♦ Graduated cylinder or other calibrated container
- ♦ Stopwatch
- ♦ Pruning scissors
- ♦ Thermometer
- ♦ Pump for transferring the 55 gallon drum to 1000 gallon drum

Table 7. Summary of Corrective Action for Field Measurements

Analysis	Units	Range	Accuracy	Corrective Action
pH	pH units	0 to 14 units	± 0.2 units	Recalibrate with new buffers; check buffer temperature
Temperature	°C	-5 to 45 °C	± 0.15 °C	Calibrate against NIST thermometer
DO	mg/L	0 to 50 mg/L	0 to 20 mg/L: ± 2.0% of the reading or 0.2 mg/L, whichever is greater 20 to 50 mg/L: ± 6.0% of the reading	Recalibrate with distilled water
Turbidity	NTU	0 to 1000 NTU	± 5.0% reading or 2 NTU, which is greater	Recalibrate with standard calibration liquids
Conductivity	mS/cm	0 to 100 mS/cm	± 0.5% reading + 0.001 mS/cm	Recalibrate with fresh potassium chloride
ORP	mV	-999 to 999 mV	± 20 mV	Recalibrate with the standard solution
Fe <sup>2+</sup>	mg/L	0 to 3.0 mg/L	± 1.0 mg/L	Recalibrate with the standard solution

## LIST OF FIGURES

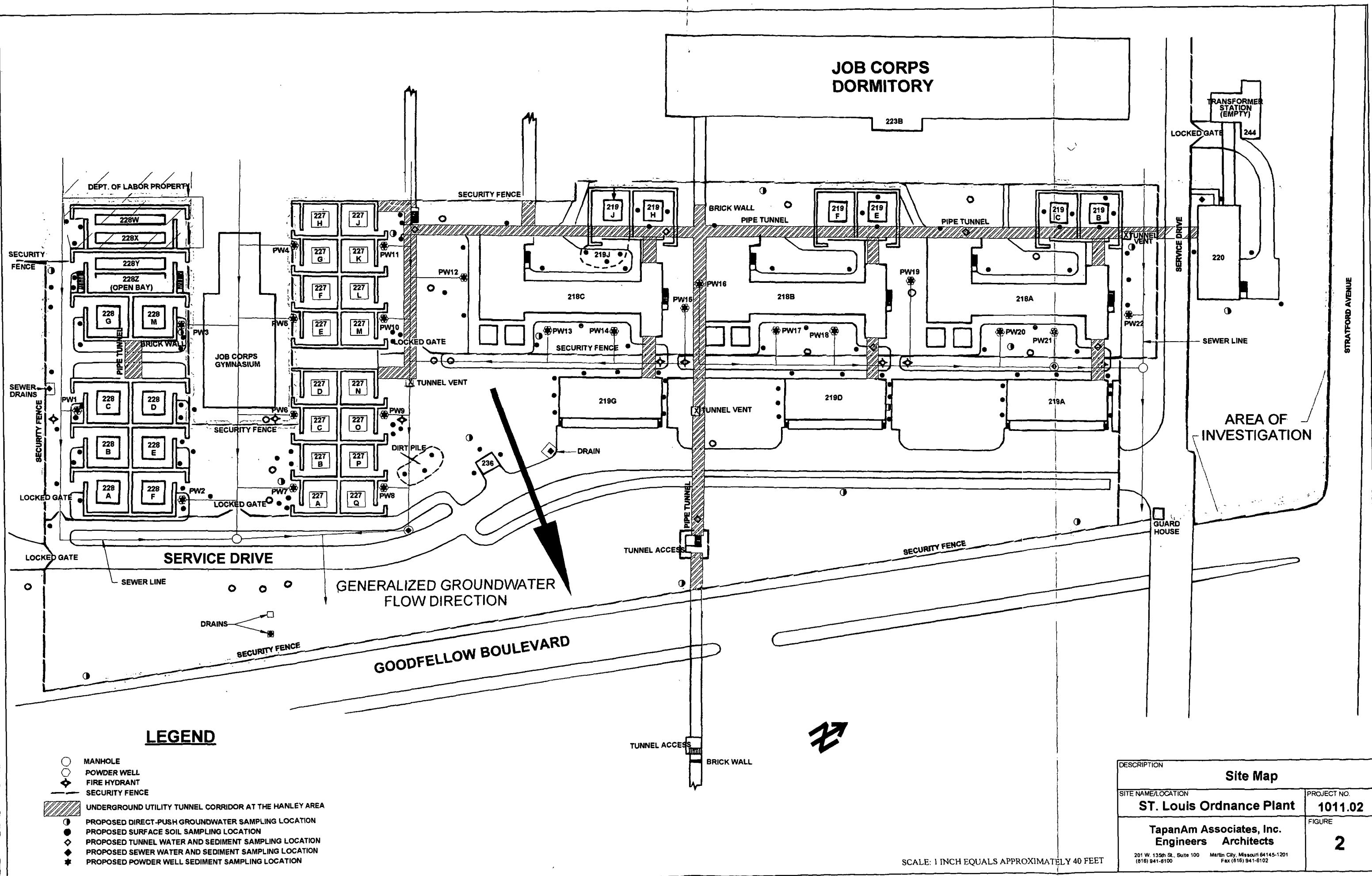


SCALE 1:24000

CONTOUR INTERVAL 10 FEET  
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Note: Topographic map is the USGS Clayton, MO.  
quadangle map, 1954, photorevised 1993.

DESCRIPTION		Site Location Map	
SITE NAME/LOCATION		PROJECT NO.	
St. Louis Ordnance Plant		1011.02	
TapanAm Associates, Inc. Engineers Architects		FIGURE	
201 W. 135th St., Suite 100 (816) 941-6100		1	
Marion City, Missouri 64145-1201 FAX (816) 941-6002			



# **LEGEND**

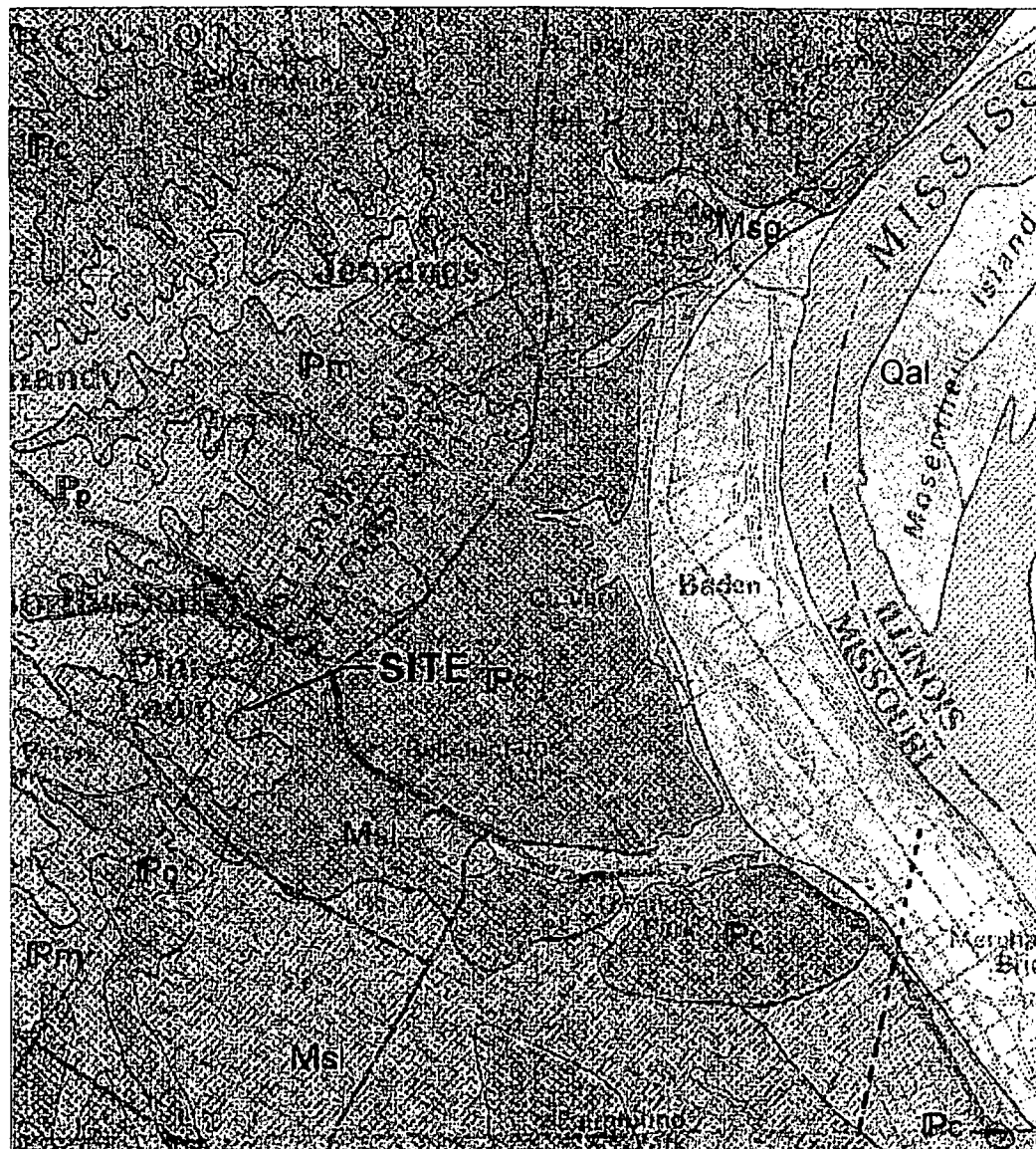
- MANHOLE
- ◇ POWDER WELL
- ◆ FIRE HYDRANT
- SECURITY FENCE
- ▨ UNDERGROUND UTILITY TUNNEL CORRIDOR AT THE HANLEY AREA
- ① PROPOSED DIRECT-PUSH GROUNDWATER SAMPLING LOCATION
- PROPOSED SURFACE SOIL SAMPLING LOCATION
- ◆ PROPOSED TUNNEL WATER AND SEDIMENT SAMPLING LOCATION
- ◆ PROPOSED SEWER WATER AND SEDIMENT SAMPLING LOCATION
- ★ PROPOSED POWDER WELL SEDIMENT SAMPLING LOCATION

SCALE: 1 INCH EQUALS APPROXIMATELY 40 FEET

DESCRIPTION		
Site Map		
SITE NAME/LOCATION	PROJECT NO.	
ST. Louis Ordnance Plant	1011.02	
TapanAm Associates, Inc. Engineers Architects		FIGURE
		2
<small>201 W. 135th St., Suite 100    Merriam City, Missouri 64145-1201 (816) 941-8100    Fax (816) 941-8102</small>		



# Geologic Map of the St. Louis Quadrangle (Site Vicinity)



## MAP LEGEND

### Quaternary System Holocene and Pleistocene Series



Alluvium (Holocene) - Gravel, sand, and silt, on flood plains of major rivers and smaller streams. Thickness ranges from 10 to 215 feet.

### Pennsylvanian System



Pleasonton Group - Shale and sandstone. As much as 100 feet thick.



Marmaton Group - Intercalated shale, limestone, clay and coal. Approximately 80 feet.



Cherokee Group - Cycles sandstone, siltstone, shale, clay, and coal. As much as 100 feet thick.

### Mississippian System



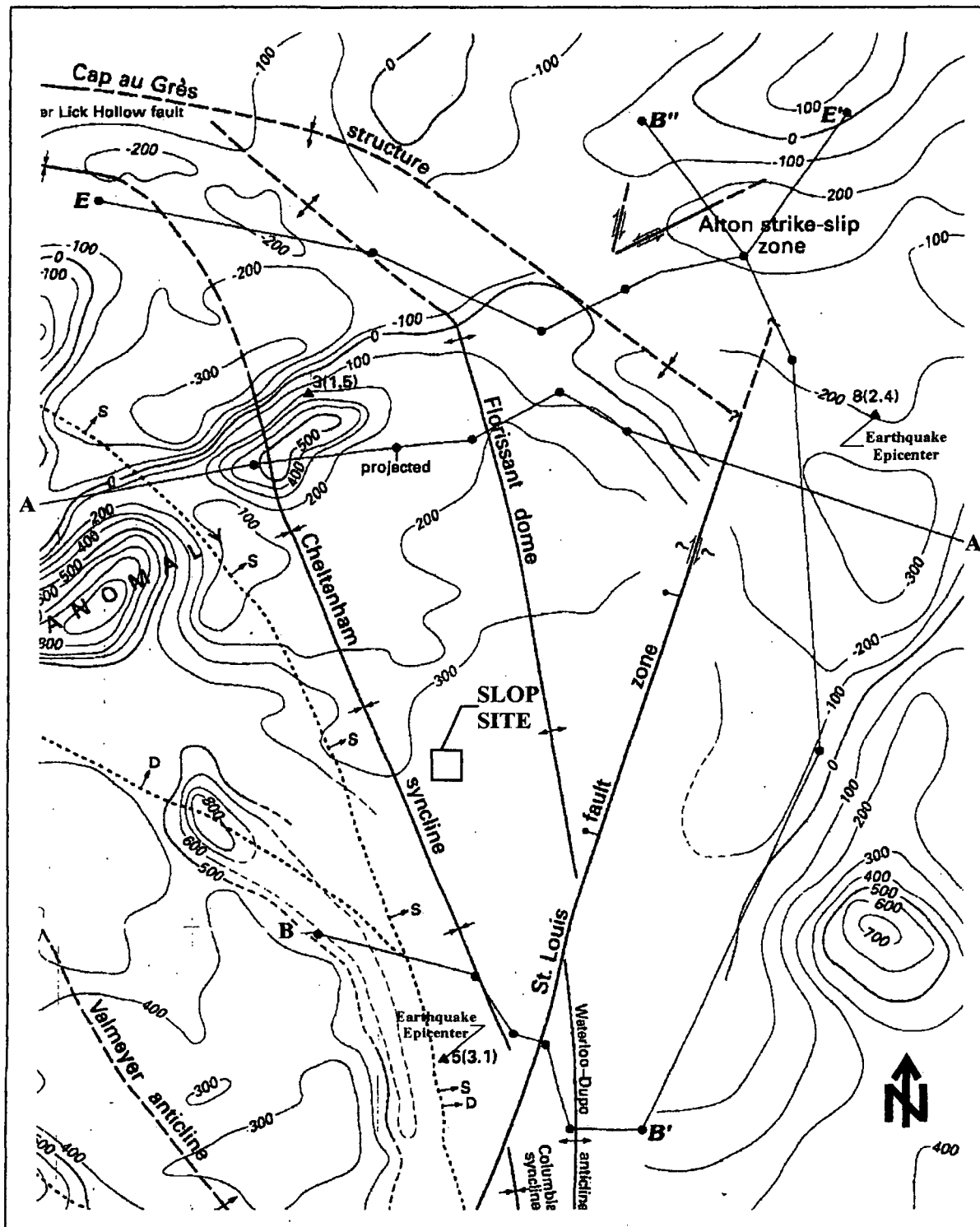
St. Genevieve Limestone - White, massive, coarsely crystalline, sandy, clastic limestone. In the St. Louis area this unit has a conglomeratic base and rests unconformably upon an eroded St. Louis Limestone. As much as 150 feet thick.



St. Louis Limestone - Dark-gray, finely crystalline to lithographic, medium bedded to massive limestone. Algal stromatolites are common. Some beds are sandy and cross laminated. From 100 to 250 feet thick.

Note: Legend is from Bedrock Geologic Map of the St. Louis 30'x60' Quadrangle, Missouri and Illinois, Harrison, 1997.

DESCRIPTION	
<b>Geologic Map of the St. Louis Quadrangle (Site Vicinity)</b>	
SITE NAME/LOCATION	PROJECT NO.
<b>St. Louis Ordnance Plant</b>	<b>1011.02</b>
FIGURE	
<b>3</b>	
<b>TapanAm Associates, Inc.</b> <b>Engineers Architects</b> 201 W. 135th St., Suite 100    Martin City, Missouri 64145-1201 (816) 941-6100    FAX (816) 941-6002	



### LEGEND

- 500 Magnetic Contour - 100 milligauss interval. Dashed where inferred.
- Fault - Dashed where uncertain. Bar and ball on downthrown side. Arrows show relative horizontal movement, where known; queried where uncertain.
- Fold - Dashed where approximately located.
- Anticline
- Syncline
- Monocline
- Pinch-out line - Om, Ordovician Maquoketa Shale; S, Silurian rocks; D, Devonian rocks. Arrow points toward occurrence.
- Earthquake epicenter - Recorded since 1974; numbers (3.1) indicate magnitude in mq.

Approximate Scale: 1 inch = 5 miles

DESCRIPTION		
<b>Regional Magnetic Anomaly Map of the St. Louis Quadrangle</b>		
SITE NAME/LOCATION		PROJECT NO.
<b>St. Louis Ordnance Plant</b>		<b>1011.02</b>
TapanAm Associates, Inc. Engineers Architects		FIGURE
201 W. 135th St., Suite 100 (816) 941-6100		<b>4</b>
Marion City, Missouri 64145-1201 FAX (816) 941-6002		

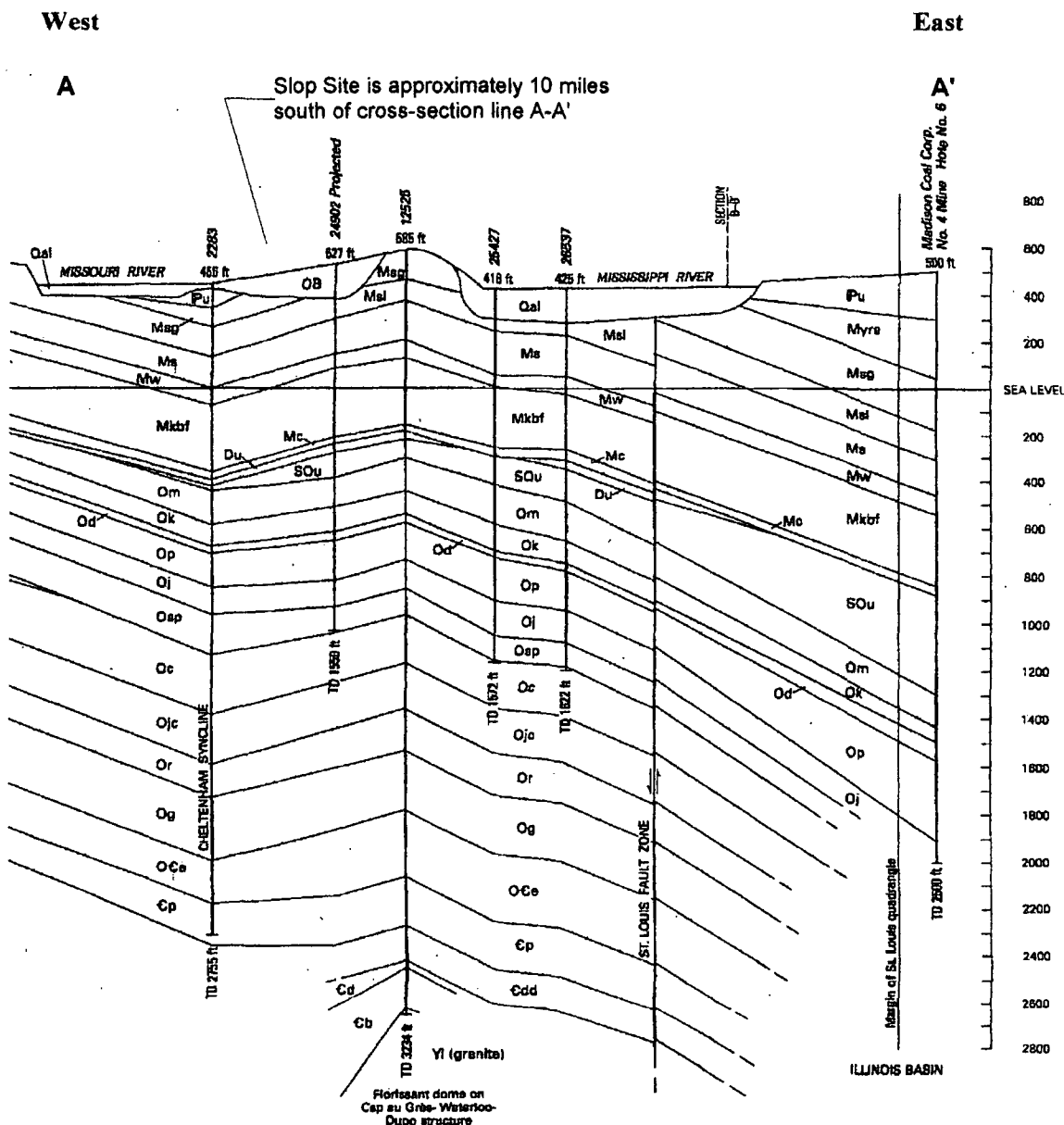
Note: USGS Bedrock Geologic Map of the St. Louis 30'x60' Quadrangle, Missouri and Illinois, was compiled by Richard W. Harrison, 1997.

# **BEDROCK GEOLOGIC LEGEND**

- Qal** — Alluvium (Holocene)
- Unconformity**
- Pu** — Pennsylvanian rocks
- Unconformity**
- Msg** — Ste. Genevieve Limestone
- Unconformity**
- Msl** — St. Louis Limestone
- Ms** — Salem Formation
- Mw** — Warsaw Formation
- Mkbf** — Keokuk & Burlington L.S. and Fern Glen Formation
- Mc** — Chouteau Limestone
- Unconformity**
- Du** — Upper and Middle Devonian rocks
- Unconformity**
- SOu** — Middle Silurian to Upper Ordovician rocks
- Unconformity**
- Om** — Maquoketa Shale
- Ok** — Kimmswick Limestone
- Od** — Decorah Group
- Op** — Platin Group
- Oj** — Joachim Dolomite
- Osp** — St. Peter Sandstone
- Unconformity**
- Opow** — Powell Dolomite
- Oc** — Cotter Dolomite
- Ojc** — Jefferson City Dolomite
- Or** — Robidoux Formation
- Unconformity**
- Og** — Gasconade Dolomite
- Unconformity**
- OCe** — Eminence Formation
- Cp** — Potosi Formation
- Unconformity**
- Cdd** — Derby and Doe Run Formations
- Cd** — Davis Formation
- Cb** — Bonnetterre Formation
- Cl** — Lamonte Formation

Fault - Dashed where uncertain. Arrows show relative horizontal movement, where known; queried where uncertain.

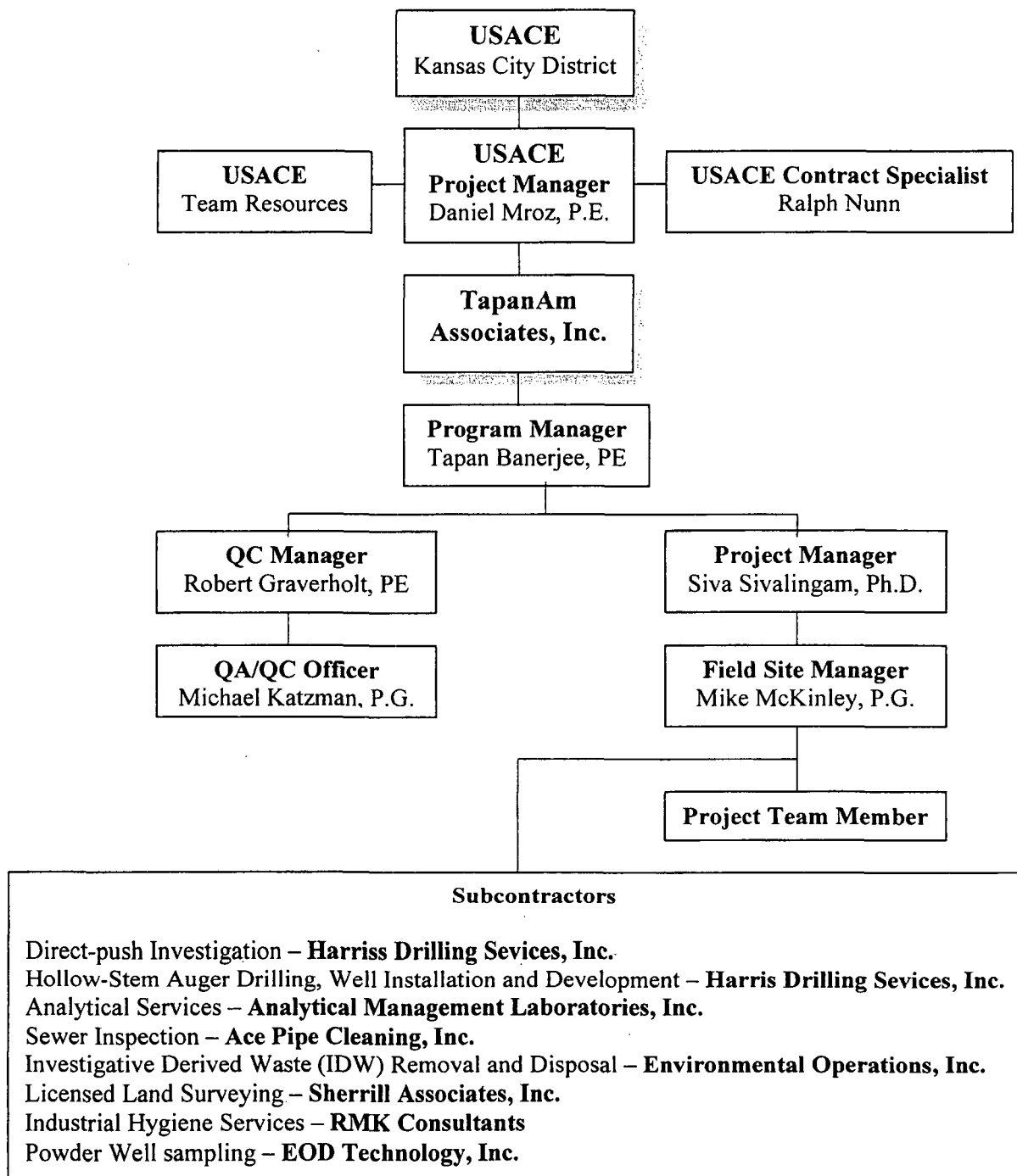
Note: USGS Bedrock Geologic Map of the St. Louis 30'x60' Quadrangle, Missouri and Illinois, was compiled by Richard W. Harrison, 1997.



Approximate Scale: 1 inch = 6 miles

DESCRIPTION		
<b>Regional Bedrock Geologic Cross-Section A-A'</b>		
SITE NAME/LOCATION		PROJECT NO.
<b>St. Louis Ordnance Plant</b>		<b>1011.02</b>
TapanAm Associates, Inc. Engineers Architects		FIGURE
201 W. 135th St., Suite 100 (816) 941-8100		<b>5</b>
Marion City, Missouri 64145-1201 FAX (816) 941-8002		

Figure 6. Project Organization  
PA/SI at the Former St. Louis Ordnance Plant, St. Louis, Missouri



## APPENDIX A-I

APPENDIX A	BORING LOGS
APPENDIX B	BOREHOLE LOGGING REQUIREMENTS
APPENDIX C	MONITORING WELL DESIGN
APPENDIX D	GENERAL REQUIREMENTS FOR MONITORING WELL INSTALLATION
APPENDIX E	MONITORING WELL CONSTRUCTION DIAGRAMS
APPENDIX F	MONITORING WELL DEVELOPMENT
APPENDIX G	WELL DEVELOPMENT DOCUMENTATION
APPENDIX H	MONITORING WELL SURVEYING
APPENDIX I	A-E RESPONSIBILITY FOR MONITORING WELLS

## APPENDIX

### A. BORING LOGS.

1. Copies of original boring logs shall be submitted as appendices to all site investigation and data summary reports. Monitoring wells and borings will not be accepted by the Government until logs are received and approved. Logs shall be prepared in accordance with "Borehole Logging Requirements" described below.

### B. BOREHOLE LOGGING REQUIREMENTS.

1. Logs shall be prepared in the field, as borings are drilled, by a qualified, experienced geologist or geotechnical engineer. Each log shall be signed by the preparer. Logs shall be of such quality that revisions will not be necessary prior to their inclusion within a report.

2. Logs shall be prepared on exact copies of CE HTW Drilling Log forms MRK 55 and MRK 55-2. Mylar copies are provided with this Scope of Work.

3. All log entries shall be printed. Photo reproductions shall be clear and legible. Illegible or incomplete logs will not be accepted. Copies shall be submitted to USACEMRK as borings are completed.

4. Borehole depth information shall be from direct measurements accurate to 0.1 ft. precision.

5. All information blanks in the log heading shall be completed.

6. Log scale shall be 1 inch = 1 foot.

7. Each and every material type encountered shall be described in column c of the log form.

a. Unconsolidated materials shall be described as follows:

(1) depositional type (e.g., alluvium, till, loess, etc.) and formation name (if named and if known)

(2) description according to the Unified Soil Classification System

(3) moisture content assessment (dry, moist, wet, saturated)

(4) consistency of cohesive materials or apparent density of noncohesive materials

(5) color using the Munsell color notation (Munsell Soil Color Chart)

(6) estimated quantities of components, mineralogy, grain or fragment size, angularity, sorting

(7) texture and primary depositional features (e.g., bedding, lamination, or other stratification characteristics)

(8) structures and secondary features (e.g., fractures, root holes, cementation, precipitates deposited in fractures or other openings)

(9) any other descriptive features (e.g., organic materials, odors, etc.)

b. Rock materials shall be described in accordance with standard geologic nomenclature, including:

(1) formation name (if known)

(2) rock type, including appropriate descriptive modifiers (e.g., fossiliferous limestone, garnet-biotite schist)

(3) relative hardness

(4) density

(5) color using the Munsell color notation (Geologic Society of America Rock Color Chart)

(6) weathering

(7) estimated quantities of components, mineralogy, grain or fragment size and texture

(8) texture (e.g., aphanitic, phaneritic, glassy, porphyritic, fine-, medium-, or coarse-grained)

(8) primary structures (depositional features, e.g., lamination, bedding, vesicularity)

(9) secondary structures and orientation (post-depositional features, e.g., fractures, joints, faults, cementation, foliation, lineation, brecciation, solution cavities, empty space coatings or fillings)

(10) any other descriptive features (e.g., fossils, odors)

(8) bedding

(9) fractures, joints and cavities

(10) other descriptive features (e.g., fossils, pits, crystals, etc.)

8. Stratigraphic/lithologic changes shall be identified in column c by a solid horizontal line at the appropriate scale depth on the log which corresponds to measured borehole depths at which changes occur. Depths shall be measured and recorded to the nearest 0.1 foot. Gradational transitions and changes identified from cuttings or methods other than direct observation and measurement shall be identified by a horizontal dashed line at the appropriate depth based upon the best judgment of the logger.

9. Logs shall clearly show in columns e and/or f, the depth intervals from which all samples were retained.

10. Logs shall clearly identify the depth at which water is first encountered, the depth to water at the completion of drilling, and the stabilized depth to water. The absence of water in borings shall also be indicated. Stabilized water level data shall include time allowed for levels to equilibrate.

11. Logs shall show borehole and sample diameters.

12. Logs shall show the depths at which any change in drilling, sampling methods, or equipment occurred.

13. Logs shall show total depth of penetration and sampling. The bottom of the hole shall be identified on the log by solid double lines from margin to margin with the notation "bottom of hole".

14. Logs shall show drilling fluids used, including, as appropriate:

- a. source of makeup water;
- b. drill fluid additives by brand and product name, and mixture proportions;
- c. type of filter for compressed air.

15. Logs shall identify any drilling fluid losses, including depths at which they occur, rate of loss, and total volume of fluid lost.

16. Logs shall show depths and types of any temporary casings used.



17. Logs shall identify any intervals of hole instability and, if applicable, subsequent cave-in.

18. Intervals of lost bedrock core shall be shown in column e. Intervals of intact soil sampling attempts shall also be shown in column e, including depths from which attempts were made and length of sample recovered from each attempt. Bedrock coring information shall be recorded in consecutively numbered runs in column h and shall include the following:

- a. start and stop time of each core run;
- b. depth to top and bottom of each core run;
- c. length of core recovered from each run;
- d. size and type of coring bit and barrel.

19. Depths of core runs shall be obtained by direct measurements with a weighted tape and recorded on the drill logs. The tape shall be constructed of materials that will not introduce contaminants into the borehole.

20. Any special drilling or sampling problems shall be recorded on logs, including descriptions of problem resolutions.

21. Logs shall include all other information relevant to a particular investigation, including but not limited to:

- a. odors;
- b. Hnu/OVA measurements;
- c. any observed evidence of contamination in samples, cuttings, or drilling fluids.

#### C. GENERAL REQUIREMENTS FOR MONITORING WELL INSTALLATION.

1. The use of any liquid is to be generally avoided during drilling and only clean, potable water will be permitted in cases where it is determined by the Government, to be absolutely necessary for successful installation of the well. If water is required during drilling or well installation, only non-chlorinated potable water will be permitted. Any proposed use of water must be approved beforehand by the Government. Chemical analyses of proposed water sources shall be required.

2. Lubricants on drill tools, drill rod joints or any other downhole equipment **shall not be used.**

3. Dispersing agents (such as phosphates) or acids shall not be used.

4. No attempts shall be made to chemically disinfect any well.

5. In accordance with the Sampling and Analysis Plan, drill rigs, drill tools, and associated equipment shall be cleaned with high pressure hot water and laboratory-grade detergent and rinsed with hot water prior to beginning drilling operations, between each boring location, and upon completion of all drilling operations.

6. Toxic and/or contaminating substances shall not be used during any part of the drilling, well installation, or well development processes. Drilling activities and methods shall be sufficient to positively prohibit the introduction of contaminants from one water bearing stratum to another via the well bore.

#### D. MONITORING WELL DESIGN.

1. Borings shall be of sufficient diameter to permit at least two (2) inches of annular space between the boring wall and all sides of the centered riser and screen. The diameter of the proposed wells shall be nominal 2 inch inside diameter.

2. The well riser shall consist of new, threaded, flush-joint, polyvinyl chloride (PVC) Schedule 40 pipe (National Sanitation Foundation Potable Water grade) with nominal two (2) inch inside diameter. Well risers shall, at a minimum, conform to the requirements of ASTM-D 1785, and shall bear manufacturers' markings that identify the material as that specified.

3. Well screen locations and lengths shall be as selected by the A-E and approved by the government. Screens shall be constructed of PVC material similar to the well riser.

4. Screen shall be noncontaminating, factory-constructed and of "continuous wrap" or "mill-slot" design. **Field slotted or cut screen shall not be used.**

5. Screen slot sizes shall be determined by the A-E and selected to be compatible with aquifer and filter pack materials. Filter pack gradation and screen slot openings shall be selected in accordance with criteria described by Driscoll (1986, Groundwater and Wells, Second Edition: St. Paul, Minnesota, Johnson Division, 1089p) or other approved criteria.

6. The A-E shall provide sieve analyses of one or more representative samples of the aquifer material in which the screen is to be placed and which demonstrates that the

screen is compatible with the aquifer material. Sieve analyses shall be conducted in accordance with ASTM C 117 and C 136, and the results shall be submitted to the government.

7. Screen and riser sections shall be joined to form water-tight unions that retain 100% of the strength of the screen. Solvent glue shall not be used at any time in construction of the wells.

8. The bottom of the deepest screen or casing section shall be sealed with a threaded PVC cap or plug.

9. Risers and screens shall be set round, plumb and true to line. Centralizers shall be used to assure concentricity and alignment of the wells. Centralizers shall not be installed on the well screen.

10. The A-E shall select and use clean, inert, noncarbonate materials to construct a uniform and continuous filter pack designed and graded to prevent migration of fines into the screen.

11. The filter pack shall be placed by tremie pipe from the bottom of the boring to approximately two (2) feet above the top of the well screen.

12. A minimum two (2) foot seal, consisting of bentonite pellets or high-solids bentonite slurry mixed to manufacturers' specifications, shall be placed into the annular space between the riser and boring wall at the top of the filter pack. Bentonite pellets shall be allowed a period of not less than twelve (12) hours to hydrate. High-solids bentonite slurry shall be allowed to hydrate as per manufacturer's specifications.

13. Cement-bentonite grout shall be placed using a side-discharge tremie pipe from the bottom of the riser to the ground surface. The cement-bentonite grout mixture shall consist of the following proportions:

- a. 94-pounds of portland cement (ASTM-C 150);
- b. not more than seven (7) gallons of clean potable water;
- c. three (3) pounds of powdered bentonite.

14. Dry components shall be thoroughly mixed before adding water.

15. Any grout placed in a monitoring well boring shall be allowed to set not less than forty-eight (48) hours before any additional work is resumed on that boring or well.

16. At all times during the progress of the work precautions shall be used to prevent tampering with the well or the entrance of foreign material into it.

17. Upon completion of a well, a vented cap shall be installed on the well riser to prevent material from entering the well.

18. The well riser shall be enclosed in a larger-diameter protective steel casing set into a concrete pad and rising 24 to 36 inches above ground level. The steel casing shall be provided with lock and cap.

19. A minimum 3 foot square, 4 inch thick concrete pad, sloped away from the well, shall be constructed around the steel protective casing at the final ground level elevation.

20. A survey marker shall be permanently placed in each pad and include the following:

- a. well identification number;
- b. survey marker and well riser elevations (measured to the nearest 0.01 ft);
- c. well coordinates (measured to the nearest 0.1 ft).

21. Three protective steel posts, 3 inches in diameter, shall be placed approximately four feet from the well, equally spaced about the well and extending one foot above the top of the steel protective casing.

22. The ground immediately surrounding the top of the well shall be sloped away from the well.

23. Two weep holes, 1/8 inch in diameter, shall be drilled in the protective casing approximately 1 inch above its base.

24. Any well to be temporarily removed from service or left incomplete due to delay in construction shall be equipped with the following:

- a. water tight cap;
- b. vandal-proof cover.

#### E. MONITORING WELL CONSTRUCTION DIAGRAMS.

1. Well construction diagrams shall be prepared and submitted for each well installed. Diagrams shall be prepared by the geologist or geotechnical engineer present during well installation. Elevations shall be surveyed by a licensed land surveyor to within 0.01 ft. Depths shall be verified during installation by measurement with a weighted tape. Construction diagrams shall accurately depict each and every component and their respective vertical positions including, but not limited to the following:

- a. total depth of well and boring (to the nearest 0.1 ft.);
- b. well location (to the nearest 0.1 ft.);
- c. boring diameter and preparation of borehole prior to installation of well;
- d. the manufacturer and quantities of all materials used in the well,

including:

- (1) type and diameter of well casing
- (2) type of well screen including length and depth, diameter, slot sizes and manufacturer
- (3) joint type
- (4) filter pack gradation, depth interval and placement method
- (5) type(s) of seal and grout
- e. construction details, including:
  - (1) date/time of construction
  - (2) any difficulties setting casing or screen
  - (3) location and type of centralizers (if used)
  - (4) placement method and depth interval of seal used, and the volume, hydration time (if applicable), manufacturer and product name of the material used (bentonite pellet seals shall be allowed to hydrate not less than twelve (12) hours prior to completing annular space backfill; high-solids bentonite slurry shall be allowed to hydrate as per manufacturer's specifications)
  - (5) amount, components, proportions, and method of grout placement (grout shall be allowed to set a minimum of forty-eight (48) hours prior to well development)

Facility/Project Name	Local Grid Location of Well Grid Origin Location Lat. _____ Long. _____ or St. _____ m. N. _____ m. E.	Well Number
Facility License, Permit or Monitoring Number	Section Location of Waste/Source _____ % of _____ % of Sec. _____ T. _____ N. R. _____ E. W.	Date Well Installed (Start)
Type of Protective Cover: Above-Ground <input type="checkbox"/> Flush-To-Ground <input type="checkbox"/>	Location of Well Relative to Waste/Source <input type="checkbox"/> Upgradient <input type="checkbox"/> Sidegradient <input type="checkbox"/> Downgradient <input type="checkbox"/> Not Known	Date Well Installed (Completed)
Well Distance From Waste/Source Boundary		Well Installed By: (Person's Name & Firm)
Maximum Depth of Frost Penetration (estimated)		

Note: Use top of casing (TOC) for all depth measurements.

A. Protective casing, top elevation \_\_\_\_\_ m. MSL

B. Well casing, top elevation \_\_\_\_\_ m. MSL

C. Land surface elevation \_\_\_\_\_ m. MSL

D. Surface seal, bottom \_\_\_\_\_ m. TOC or \_\_\_\_\_ m. MSL

16. USCS classification of soil near screen:

GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☐  
 SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐  
 Bedrock ☐

17. Sieve analysis attached? ☐ Yes ☐ No

18. Drilling method used: Rotary ☐  
Hollow Stem Auger ☐  
Other ☐

19. Drilling fluid used: Water ☐ Air ☐  
Drilling Mud ☐ None ☐

20. Drilling additives used? ☐ Yes ☐ No  
Describe \_\_\_\_\_

21. Source of water (attach analysis):  
\_\_\_\_\_

1. Cap and lock? ☐ Yes ☐ No

2. Protective posts? ☐ Yes ☐ No

3. Protective casing:  
a. Inside diameter: \_\_\_\_\_ mm.  
b. Length: \_\_\_\_\_ m.

4. Drainage port(s) ☐ Yes ☐ No

5. Surface seal:  
a. Cap \_\_\_\_\_ Gravel blanket ☐  
Bentonite ☐  
Concrete ☐  
Other ☐  
b. Annular space seal: Bentonite ☐  
Cement ☐  
Other ☐

6. Material between well casing and protective casing: Bentonite ☐  
Cement ☐  
Other ☐

7. Annular space seal:  
a. Granular Bentonite ☐  
b. \_\_\_\_\_ lbs/gal mud weight... Bentonite-sand slurry ☐  
c. \_\_\_\_\_ lbs/gal mud weight... Bentonite slurry ☐  
d. \_\_\_\_\_ x Bentonite \_\_\_\_\_ Bentonite-cement grout ☐  
e. \_\_\_\_\_ m.<sup>3</sup> volume added for any of the above

8. How installed: Tremie ☐  
Tremie pumped ☐  
Gravity ☐

8. Centralizers ☐ Yes ☐ No

9. Secondary Filter ☐ Yes ☐ No  
a. Volume added \_\_\_\_\_ m.<sup>3</sup> \_\_\_\_\_ Bags/Size

10. Bentonite seal:  
a. Bentonite granules ☐  
b. ☐ 1/4 in. ☐ 1/2 in. ☐ 3/4 in. Bentonite pellets ☐  
c. \_\_\_\_\_ Other ☐

11. Secondary Filter ☐ Yes ☐ No  
a. Volume added \_\_\_\_\_ m.<sup>3</sup> \_\_\_\_\_ Bags/Size

12. Filter pack material: Manufacturer, product name & mesh size  
a. \_\_\_\_\_  
b. Volume added \_\_\_\_\_ m.<sup>3</sup> \_\_\_\_\_ Bags/Size

13. Well casing: Flush threaded PVC schedule 40 ☐  
Flush threaded PVC schedule 80 ☐  
Other ☐

14. Screen material:  
a. Screen type: Factory cut ☐  
Continuous slot ☐  
Other ☐  
b. Manufacturer \_\_\_\_\_  
c. Slot size: \_\_\_\_\_ in.  
d. Slotted length: \_\_\_\_\_ m.

15. Backfill material (below filter pack): None ☐  
Other ☐

E. Secondary filter, top \_\_\_\_\_ m. TOC or \_\_\_\_\_ m. MSL

F. Bentonite seal, top \_\_\_\_\_ m. TOC or \_\_\_\_\_ m. MSL

G. Secondary filter, top \_\_\_\_\_ m. TOC or \_\_\_\_\_ m. MSL

H. Primary filter, top \_\_\_\_\_ m. TOC or \_\_\_\_\_ m. MSL

I. Screen joint, top \_\_\_\_\_ m. TOC or \_\_\_\_\_ m. MSL

J. Well bottom \_\_\_\_\_ m. TOC or \_\_\_\_\_ m. MSL

K. Filter pack, bottom \_\_\_\_\_ m. TOC or \_\_\_\_\_ m. MSL

L. Borehole, bottom \_\_\_\_\_ m. TOC or \_\_\_\_\_ m. MSL

M. Borehole, diameter \_\_\_\_\_ mm.

N. O.D. well casing \_\_\_\_\_ mm.

O. I.D. well casing \_\_\_\_\_ mm.

P. 24-hr water level after completion \_\_\_\_\_ m. TOC or \_\_\_\_\_ m. MSL

Schematic construction diagram of monitoring well

(6) ground elevation, riser elevation, and description of protective pad and cap, including height the pad extends above the ground surface and depth it extends into the borehole

(7) any deviation from the work plan

f. static water levels and length of time after well completion water level was taken.

2. Diagrams shall be of such quality that revisions will not be necessary prior to their inclusion within a report.

#### F. MONITORING WELL DEVELOPMENT.

1. Monitoring wells shall be developed no sooner than forty-eight (48) hours after grouting is completed. Development methods shall ensure that formation damage due to drilling and well construction has been corrected and well efficiency is maximized. The A-E shall direct a program for the development of each well by alternate pumping, bailing, and vigorous surging, without the use of acids, dispersing agents, or explosives. Surging shall be accomplished by the reciprocating motion of a surge block in the screened portion of the well.

2. Information to be recorded before and after development of each well shall include:

- a. water levels;
- b. depth of well;
- c. turbidity;
- d. dissolved oxygen;
- e. specific conductance;
- f. pH;
- g. temperature;

3. Development shall continue until all the following criteria are satisfied:

- a. water samples for chemical analysis will be at 30 NTU or less;

- b. samples will be free of sand and drilling fluids;
  - c. groundwater parameter measurements of dissolved oxygen, conductivity, pH, and temperature have stabilized;
  - d. not less than five times the volume of fluid lost during drilling and filter pack placement is removed.
4. Water or liquids, other than formation water from that well, shall not be introduced into a well.

#### G. WELL DEVELOPMENT DOCUMENTATION.

1. Well development records shall be prepared and submitted for each well installed. Records shall be prepared by the geologist or geotechnical engineer present during drilling, well construction, and well development. Information to be provided in the development records shall include, but will not be limited to, the following:

- a. dates and times of well development;
- b. elapsed time between grouting and well development (minimum 48 hours);
- c. descriptions of all equipment used for development;
- d. water levels in wells prior to commencing development process;
- e. well development methods, including:
  - (1) the amount of water pumped (expressed as gallons and as equivalent borehole volumes)
  - (2) surging technique
  - (3) time performed
  - (4) bailing operations
- f. description of changes in the water removed during development, including:
  - (1) clarity



(2) color

(3) particulates

(4) odor

g. criteria used to determine when well development was complete (e.g., turbidity, dissolved oxygen, specific conductance, pH, temperature, color, etc.);

h. water levels in wells upon completion of development; and

i. color photographs of the water after development has been completed.

2. Development and purging documentation shall be of such quality that revisions are not necessary prior to its inclusion within a report.

#### H. MONITORING WELL SURVEYING.

1. Monitoring well pad and riser elevations shall be surveyed.

2. A 3.5 inch diameter, domed survey marker composed of brass, bronze, or aluminum alloy shall be permanently set in the concrete pad surrounding each well. The survey marker shall include the following information:

a. well identification number;

b. well coordinates (measured to the nearest 0.1 ft.);

c. survey marker and well riser elevations (measured to the nearest 0.01 ft.).

3. The coordinates shall be to the closest 0.1 foot and referenced to the State Plane Coordinate System. If the state Plane Coordinate System is not readily available, the existing local grid system shall be used.

4. Elevations shall be provided to the closest 0.01 foot and referenced to the National Geodetic Vertical Datum of 1929. If the 1929 Datum is not readily available, the existing local vertical datum shall be used.

#### I. A-E RESPONSIBILITY FOR MONITORING WELLS.

1. It is the responsibility of the A-E to properly plan, design, install, develop, and test monitoring wells so that they are suitable to produce groundwater samples representative in quantity and quality of subsurface conditions. The A-E shall ensure that the requirements of this scope of work and best construction practices are carried out.

2. If the A-E, due to inadequate design or construction, installs monitoring wells that are not functional or not in accordance with specifications, the Contracting Officer may disapprove the well and direct the A-E to repair or replace it at the Contracting Officer's discretion. This work shall be done at no additional cost to the Government.

3. If a monitoring well is rejected by the Contracting Officer, or is abandoned by the A-E for any reason, the well shall be abandoned in accordance with state regulations and as directed by the Contracting Officer at no additional cost to the Government.

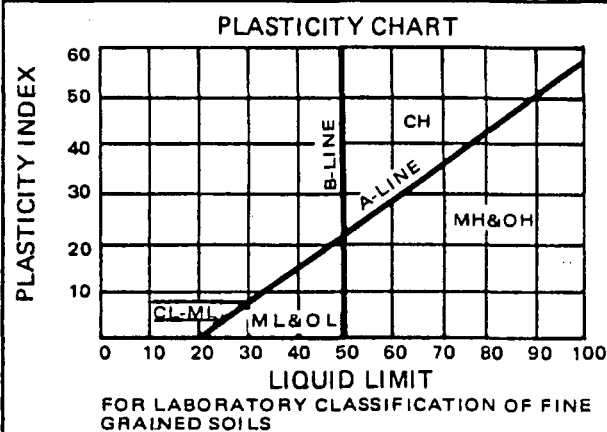
## APPENDIX J

### FIELD FORMS

UNIFIED SOIL CLASSIFICATION SYSTEM  
HTW DRILLING LOG  
DAILY QUALITY CONTROL REPORT  
DAILY FIELD SAMPLING REPORT  
WATER LEVEL MEASUREMENT  
WELL DEVELOPMENT LOG  
WELL PURGING RECORD  
GROUNDWATER SAMPLE LOG  
SAMPLE LOG  
CHAIN OF CUSTODY  
FIELD CALIBRATION REPORT  
VARIANCE FORM  
VARIANCE LOG

# Unified Soil Classification System

MAJOR DIVISIONS			LETTER SYMBOL	DESCRIPTION
COARSE-GRAINED SOILS MORE THAN 50% LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS	GW	WELL-GRADED GRAVEL, GRAVEL-SAND MIXTURE
		LITTLE OR NO FINES	GP	POORLY-GRADED GRAVEL, GRAVEL-SAND MIXTURE
		GRAVELS WITH FINES	GM	SILTY GRAVEL, GRAVEL-SAND-SILT MIXTURE
		APPRECIABLE FINES	GC	CLAYEY-GRAVEL, GRAVEL-SAND-CLAY MIXTURE
	SAND AND SANDY SOILS	CLEAN SANDS	SW	WELL-GRADED SAND, GRAVELLY SAND
		LITTLE OR NO FINES	SP	POORLY-GRADED SAND, GRAVELLY SAND
		SANDS WITH FINES	SM	SILTY SAND, SAND-SILT MIXTURE
		APPRECIABLE FINES	SC	CLAYEY SAND, SAND-CLAY MIXTURE
FINE-GRAINED SOILS MORE THAN 50% SMALL- ER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50	ML	SILT, CLAYEY SILT, SILTY OR CLAYEY VERY FINE SAND, SLIGHT PLASTICITY
			CL	CLAY, SANDY CLAY, SILTY CLAY, LOW TO MEDIUM PLASTICITY
			OL	ORGANIC SILTS OR SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT MORE THAN 50	MH	SILT, FINE SANDY OR SILTY SOIL WITH HIGH PLASTICITY
			CH	CLAY, HIGH PLASTICITY
			OH	ORGANIC CLAY OF MEDIUM TO HIGH PLASTICITY
			HIGHLY ORGANIC SOILS	



RELATIVE PARTICLE SIZE	
BOULDER	LARGER THAN 12"
COBBLE	3" TO 12"
GRAVEL COARSE	3/4" TO 3"
FINE	4.76MM TO 3/4"
SAND COARSE	2MM TO 4.76MM
MEDIUM	0.42MM TO 2MM
FINE	0.074MM TO 0.42MM
SILTS AND CLAY	SMALLER THAN 0.074MM

RELATIVE PLASTICITY	
NONPLASTIC	CANNOT ROLL INTO BALL
TRACE PLASTICITY	BARELY ROLL INTO BALL
MEDIUM PLASTIC	CAN BE ROLLED INTO BALL
HIGHLY PLASTIC	NO RUPTURE BY KNEADING

RELATIVE COMPOSITION	
TRACE	0-10%
SOME	11-35%
AND/WITH	36-50%

RELATIVE MOISTURE		DENSITY	N-VALUE
DRY	POWDERY	VERY LOOSE	0-4
DAMP	BELOW PLASTIC LIMIT	LOOSE	5-10
MOIST	PL TO LL RANGE	MEDIUM	11-30
WET	ABOVE LIQUID LIMIT	DENSE	31-50
		VERY DENSE	>50

RELATIVE CONSISTENCY	
VERY SOFT	< 1/4 TSF
SOFT	1/4-1/2 TSF
MEDIUM	1/2-1 TSF
STIFF	1-2 TSF
VERY STIFF	2-4 TSF
HARD	> 4 TSF

N-VALUE (BLOW COUNT) IS THE STANDARD PENETRATION RESISTANCE BASED ON THE TOTAL NUMBER OF BLOWS, USING A 140-LB HAMMER WITH 30-INCH FREE FALL, REQUIRED TO DRIVE A SPLIT-SPOON THE LAST TWO OF THREE 6-INCH DRIVE INCREMENTS. (EXAMPLE: 4/7/9, N = 7+9=16)

# HTW DRILLING LOG

HOLE NO.

1. COMPANY NAME

2. DRILLING SUBCONTRACTOR

SHEET 1  
OF SHEETS

3. PROJECT

4. LOCATION

5. NAME OF DRILLER

6. MANUFACTURER'S DESIGNATION OF DRILL

7. SIZES AND TYPES OF DRILLING  
AND SAMPLING EQUIPMENT

8. HOLE LOCATION

9. SURFACE ELEVATION

10. DATE STARTED

11. DATE COMPLETED

12. OVERBURDEN THICKNESS

15. DEPTH GROUNDWATER ENCOUNTERED

13. DEPTH DRILLED INTO ROCK

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED

14. TOTAL DEPTH OF HOLE

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)

18. GEOTECHNICAL SAMPLES

DISTURBED

UNDISTURBED

19. TOTAL NUMBER OF CORE BOXES

20. SAMPLES FOR CHEMICAL ANALYSIS

VOC

METALS

OTHER (SPECIFY)

OTHER (SPECIFY)

OTHER (SPECIFY)

21. TOTAL CORE  
RECOVERY  
%

22. DISPOSITION OF HOLE

BACKFILLED

MONITORING WELL

OTHER (SPECIFY)

23. SIGNATURE OF INSPECTOR

ELEV.  
a

DEPTH  
b

DESCRIPTION OF MATERIALS  
c

FIELD SCREENING  
RESULTS  
d

GEOTECH SAMPLE  
OR CORE BOX NO.  
e

ANALYTICAL  
SAMPLE NO.  
f

BLOW  
COUNTS  
g

REMARKS  
h

# HTW DRILLING LOG

HOLE NO.

PROJECT

INSPECTOR

SHEET  
OF SHEETS

ELEV.  
a

DEPTH  
b

DESCRIPTION OF MATERIALS  
c

FIELD SCREENING  
RESULTS  
d

GEOTECH SAMPLE  
OR CORE BOX NO.  
e

ANALYTICAL  
SAMPLE NO.  
f

BLOW  
COUNTS  
g

REMARKS  
h

PROJECT

HOLE NO.

## Daily Quality Control Report

### GENERAL

Site: \_\_\_\_\_  
Project No: \_\_\_\_\_  
Date: \_\_\_\_\_  
Crew No: \_\_\_\_\_  
Size of Crew: \_\_\_\_\_  
Equipment on Site: \_\_\_\_\_

Subcontractors on Site: \_\_\_\_\_

Visitors on Site: \_\_\_\_\_

### WEATHER CONDITIONS (Circle One)

1. General:	Bright Sun	Clear	Overcast	Rain	T-Storm	Snow
2. Temperature:	<32°F	32-50°F	50-70°F	70-85°F	>85°F	_____
3. Wind Direction:	N	S	E	W	NW	SW NE SE _____
4. Wind Speed:	Still	Gusty	Moderate	High	_____	_____
5. Humidity:	Dry	Moderate	Humid	_____	_____	_____

### FIELD ANALYTICAL EQUIPMENT (Check or Circle One)

Instrument:	OVM	LEL	PID	FID	pH	Cod.	Turbidity	Temp.
Calibrated:	_____	_____	_____	_____	_____	_____	_____	_____
Calib. Record Present?	_____	_____	_____	_____	_____	_____	_____	_____

SUMMARY OF WORK PERFORMED: \_\_\_\_\_

### PROBLEMS ENCOUNTERED / CORRECTIVE ACTION TAKEN (Circle One):

Project Manager Contacted? Yes No Explain: \_\_\_\_\_

### SAMPLING

Samples collected in accordance with SAP?	NA	Yes	No	_____
Contingency Sampling Performed?	NA	Yes	No	_____

NAME: \_\_\_\_\_ Signature: \_\_\_\_\_ Date: \_\_\_\_\_

[REDACTED]

[illegible]



## WATER LEVEL MEASUREMENTS

Project Name: \_\_\_\_\_

Date: \_\_\_\_\_

Water Level Indicator ID No.: \_\_\_\_\_

Field Logbook No.: \_\_\_\_\_

Location: \_\_\_\_\_

Page No.: \_\_\_\_\_

Monitoring Well No.	Time	Depth to Static Water Level (TOC) (ft)	Total Well Depth (ft)	PID Reading (above background)

Comments: \_\_\_\_\_

---

---

---

Sampler: \_\_\_\_\_

Observer: \_\_\_\_\_

# WELL DEVELOPMENT LOG

Project No.:

Well No.: \_\_\_\_\_

Site: \_\_\_\_\_

Contractor:

Development Start: \_\_\_\_\_

Developed by: \_\_\_\_\_

Development End: \_\_\_\_\_

Casing Diameter: \_\_\_\_\_

**Development Method:**

Equipment:

Pre-Dev. SWL:

Maximum drawdown during pumping: \_\_\_\_\_ ft at \_\_\_\_\_ gpm

Range and average discharge rate: \_\_\_\_\_

Total quantity of material bailed: \_\_\_\_\_

Total quantity of water discharged by pumping:

Disposition of discharge water: \_\_\_\_\_

[illegible]

## WELL PURGING RECORD

[illegible]

## GROUNDWATER SAMPLING LOG

Project Name: \_\_\_\_\_

Location: \_\_\_\_\_

Site: \_\_\_\_\_

### SAMPLE INFORMATION

Sampling Method: \_\_\_\_\_

Date: \_\_\_\_\_

Sample ID: \_\_\_\_\_

Time: \_\_\_\_\_

Grab ( )      Composite ( )

Size/Type of Container	Preservative/ Preservation	Extraction Method	Analytical Method	Analysis

Notable Observations		
PID Readings	Sample Characteristics	Miscellaneous
1 <sup>st</sup>	Color:	
2 <sup>nd</sup>	Odor:	
	Other:	

### GENERAL INFORMATION

**Weather:**

Sun/Clear \_\_\_\_\_ Overcast/Rain \_\_\_\_\_ Wind Direction \_\_\_\_\_ Ambient Temp. \_\_\_\_\_

**Shipment via:**

FedEx \_\_\_\_\_ Hand Deliver \_\_\_\_\_ Courier \_\_\_\_\_ Other \_\_\_\_\_

Comments: \_\_\_\_\_

Sampler: \_\_\_\_\_ Observer: \_\_\_\_\_

## Sample Label

TapanAm Associates, Inc. Former St. Louis Ordnance Plant, St. Louis County Missouri		Sample Number	
Sample Type	Matrix	Preservative	
<u>Container Information</u> No.:            Size:            Type:			
Analysis:			
Method:			
Sample Date: _____ Sample Time: _____ Sampler's Initials: _____			



1 [REDACTED] B S [REDACTED] Ke [REDACTED]  
Olathe, Kansas 66062  
Phone (913) 829-0101  
Fax (913) 829-1181

Page \_\_\_\_ of \_\_\_\_

### Chain of Custody Record / Request for Analysis

Client Contact Name: \_\_\_\_\_  
 Company Name: \_\_\_\_\_  
 Address: \_\_\_\_\_  
 City, State, Zip: \_\_\_\_\_  
 Phone #: (      ) \_\_\_\_\_  
 Fax #: (      ) \_\_\_\_\_

Project Name: \_\_\_\_\_  
Project Number: \_\_\_\_\_  
Purchase Order Number: \_\_\_\_\_  
Project Due Date: \_\_\_\_\_  
Project Comments: \_\_\_\_\_  
Sampler's Signature: \_\_\_\_\_

**Analyses/Method to be Performed (Check all that apply)**

[illegible]

C U S T O D Y	Relinquished By:		Date/Time:		Received By:		Date/Time:	
	Relinquished By:		Date/Time:		Received By:		Date/Time:	

By signing the request (chain of custody) you are ordering work from Analytical Management Laboratories, Inc. which constitutes the acceptance of the terms and conditions on the back of this form.

<b>Delivery Method</b> <input type="checkbox"/> Delivered in Person <input type="checkbox"/> Courier _____ <input type="checkbox"/> Airbill # _____	<b>Custody Seals</b> <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Intact <input type="checkbox"/> Broken	<b>Coolant</b> <input type="checkbox"/> Ice <input type="checkbox"/> Blue Ice <input type="checkbox"/> None	<b>Cooler Temp.</b> _____ °C <input type="checkbox"/> Temp. Blank <input type="checkbox"/> Cooler	<b>Receiving Comments:</b>    
--	--	--	--	--

# FIELD CALIBRATION REPORT

**Project Name:** \_\_\_\_\_

**Equipment:** \_\_\_\_\_

**Project No.:** \_\_\_\_\_

**Serial No.:** \_\_\_\_\_

[illegible]

## VARIANCE FORM

VARIANCE NO. _____	
PROJECTNUMBER: _____	PAGE ____ OF ____
PROJECT NAME: _____	DATE _____
VARIANCE (INCLUDE JUSTIFICATION)	
APPLICABLE DOCUMENT:	
CC:	REQUESTED BY: _____ DATE _____
	APPROVED BY: _____ DATE _____
	Project Manager
	_____ DATE _____
	QA Manager/Auditor
	_____ DATE _____



## VARIANCE LOG

## CHRONOLOGIC LIST OF PROJECT VARIANCES

**PROJECT MANAGER:** \_\_\_\_\_ **PAGE** \_\_\_\_\_ **OF** \_\_\_\_\_

**PROJECT NAME:**

[illegible]

APPENDIX K

SITE VICINITY WATER WELL  
RECORDS/BORING LOGS

IN	REFIDN	OWNER_LAST	OWN ADD_1	CITY	USE BUSINESS_N	REC_TYPE	Q_1	Q_2	Q_3	SEC	TWR	RNG	TOTAL_DP-TN	CASING_L	TEST_YLD
1	0123145A	JENNINGS STA.SIT	3113 WEST OLD HIGGINS RD.	ELK GROVE VILLAGE	M ALLIED SERVICES DIV. SEV.	A				30	46N	07E	13	0	0
2	0129101A	CRISMAN	4100 UNION BLVD.	ST. LOUIS	M H.B. FULLER CO.	A				27	46N	07E	20	0	0
3	0114060G	BOARD OF PUB.SCR	CITY HALL RR. 305	ST. LOUIS	M CITY OF ST. LOUIS	A	HE	SW	SW	20	46N	07E	14	0	0
4	0103039A	JEFSEN	6425 W FLORISSANT AVENUE	ST LOUIS		A	HE	SW	SW	20	46N	07E	15	0	0
5	0132566A	MORRIS	5842 NATURAL BRIDGE RD	ST LOUIS	M MORRIS AUTO REPAIR	A				31	46N	07E	30	0	0
6	0145020A		1200 W COUNTY RD E	ARDEN HILLS	M H.B. FULLER CO	M				32	46N	07E	38	0	0
7	0152450A		5105 BROWN AVENUE	ST LOUIS	M MID AMERICA FIBER CO	A				32	46N	07E	18	0	0



MISSOURI DEPARTMENT OF  
NATURAL RESOURCES  
DIVISION OF GEOLOGY AND  
LAND SURVEY  
**MONITORING WELL  
CERTIFICATION RECORD**

<b>OFFICE USE ONLY</b>		<b>DATE RECEIVED</b>	
REF. NO.	145020	RECEIVED SEP 3 1996	
C.R. NO.		CHECK NO.	4505
STATE WELL NUMBER	A57402	TRANSMITTAL NO.	
CHECKED BY	W6	ROUTE	PCD 888798
APPROVED BY		ENTERED	

**INFORMATION SUPPLIED BY MONITORING WELL CONTRACTOR**

SITE/FACILITY NAME <b>H.B. Fuller Company</b>		WELL NUMBER <b>MW-11</b>	
SITE ADDRESS <b>4100 Union Blvd.</b>		CITY <b>St. Louis</b>	STATE <b>MO</b>
OWNER NAME <b>H.B. Fuller Company</b>		TELEPHONE <b>(612) 481-4881</b>	
OWNER ADDRESS <b>1200 W. County Rd. E</b>		CITY <b>Arden Hills</b>	STATE <b>MN</b>
VARIANCE <input type="checkbox"/> YES ISSUED <input checked="" type="checkbox"/> NO		DATE ISSUED	COUNTY <b>St. Louis</b>
VARIANCE NUMBER <b>V</b>		SURFACE ELEVATION <b>N/A</b>	
DESCRIBE LOCATION OF THE WELL SO WE WOULD BE ABLE TO VISIT IT <b>Approx. 30' East of Centerline of H.B. Fuller Warehouse</b>			
SMALLEST 1/4 <b>N/A</b>		LARGEST 1/4 <b>N/A</b>	
SEC. <b>33</b>		TWN. <b>46</b>	
LAT. <b>38 40 57</b>		LONG. <b>90 15 24</b>	

CONTRACTOR'S NAME <b>Charley Roberts - Roberts Environmental Drilling</b>	PERMIT NUMBER <b>001148 WPA</b>
DRILLING CONTRACTOR'S NAME <b>Charley Roberts</b>	PERMIT NUMBER <b>001148 WPA</b>

<b>WELL CONSTRUCTION INFORMATION</b>							
TYPE OF WELL <input checked="" type="checkbox"/> MONITORING WELL <input type="checkbox"/> PIEZOMETER <input type="checkbox"/> OTHER	TYPE OF POTENTIAL SITE <input checked="" type="checkbox"/> HAZARDOUS MATERIAL <input type="checkbox"/> LANDFILL <input type="checkbox"/> OTHER <input checked="" type="checkbox"/> LUST		MONITORING FOR: (CHECK ALL THAT APPLY) <input checked="" type="checkbox"/> V.O.C. <input type="checkbox"/> METALS <input checked="" type="checkbox"/> PETROLEUM PRODUCT ONLY				
PROTECTIVE CASING DETAILS (IF USED) LENGTH <b>1</b> FT. DIAMETER OF CASING <b>4</b> IN. WEIGHT OR SDR <b>12</b>	DIAMETER AND DEPTH OF DRILL HOLE <b>14</b> FT.		JOINTS <input checked="" type="checkbox"/> MECHANICAL <input type="checkbox"/> THREADED <input type="checkbox"/> WELDED <input type="checkbox"/> OTHER		MATERIAL <input checked="" type="checkbox"/> STEEL <input type="checkbox"/> THERMO PLASTIC <input type="checkbox"/> FLUORO POLYMER		LOCKING CAP <input checked="" type="checkbox"/> YES <input type="checkbox"/> NO
CAP VENTED <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO WEEP HOLE <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO	CASING GROUT DETAILS MATERIAL <input checked="" type="checkbox"/> CEMENT <input type="checkbox"/> CONCRETE <input type="checkbox"/> OTHER		DEPTH FROM THE SURFACE TO THE BOTTOM OF THE CASING UTILITY SEAL <b>1</b> FT.		TYPE OF SURFACE COMPLETION <input type="checkbox"/> ABOVE GROUND <input checked="" type="checkbox"/> FLUSH MOUNT		DESCRIBE HOW THE FLUSH MOUNT WAS CONSTRUCTED <b>A 14" dia. hole was drilled to 1' deep &amp; the grout was concentrated in place</b>
CENTRALIZER USED ON RISER <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO	DIAMETER OF RISER PIPE <b>4</b> IN.		WEIGHT OR SDR <b>Sch. 40</b>		DIAMETER OF DRILL HOLE <b>10-75</b> IN.		JOINTS <input checked="" type="checkbox"/> THREADED <input type="checkbox"/> MECHANICAL <input type="checkbox"/> WELDED <input type="checkbox"/> OTHER
RISER PIPE DETAILS LENGTH <b>23'</b>	DIAMETER OF RISER PIPE <b>4</b> IN.		WEIGHT OR SDR <b>Sch. 40</b>		DIAMETER OF DRILL HOLE <b>10-75</b> IN.		JOINTS <input checked="" type="checkbox"/> THREADED <input type="checkbox"/> MECHANICAL <input type="checkbox"/> WELDED <input type="checkbox"/> OTHER
ANNULAR SEAL <input type="checkbox"/> CEMENT SLURRY <input type="checkbox"/> BENTONITE SLURRY <input checked="" type="checkbox"/> NON SLURRY BENTONITE TYPE: <b>CHIPS - 1/2" x 1/4"</b>	CEMENT/BENTONITE SLURRY BAGS OF CEMENT USED % BENTONITE USED WATER USED/BAG		BENTONITE SEAL <input type="checkbox"/> SLURRY <input checked="" type="checkbox"/> CHIPS <input type="checkbox"/> GRANULAR <input type="checkbox"/> PELLETS		LENGTH OF SEAL <b>4'</b>		REMARKS: (IF APPLICABLE) <input checked="" type="checkbox"/> UNSATURATED ZONE <input checked="" type="checkbox"/> SATURATED ZONE
PRIMARY FILTER PACK TYPE <input checked="" type="checkbox"/> SAND <input type="checkbox"/> MANUFACTURED <input type="checkbox"/> NATURAL	GRAIN SIZE <b>10-20</b>		LENGTH OF FILTER PACK <b>17</b> FT.		METHOD OF INSTALLATION <b>Gravity</b>		Indications in this column to be supplied in the Field from surface column
SECONDARY FILTER PACK TYPE <input type="checkbox"/> SAND <b>N/A</b> <input type="checkbox"/> MANUFACTURED <input type="checkbox"/> NONE	GRAIN SIZE <b>N/A</b>		LENGTH OF FILTER PACK <b>N/A</b> FT.		METHOD OF INSTALLATION <b>N/A</b>		Depth to bottom of Protective Casing Seal <b>1'</b>
WELL SCREEN LENGTH OF SCREEN <b>15</b> FT.	DIAMETER <b>4</b> IN.		SLOT SIZE <b>10-10</b>		WEIGHT OR SDR <b>Sch. 40</b>		Material <input checked="" type="checkbox"/> PLASTIC <input type="checkbox"/> STEEL <input type="checkbox"/> FLUORO POLYMER
BUMP DETAILS LENGTH OF BUMP <b>N/A</b>	DIAMETER OF BUMP <b>N/A</b>		MATERIAL <input type="checkbox"/> PVC <input type="checkbox"/> FLUORO POLYMER <input type="checkbox"/> OTHER		LENGTH OF BACK FILLED BORE HOLE <b>N/A</b>		Depth to Base of Bump - East <b>21'</b>
BACK FILL WAS THE WELL BACK FILLED? <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO	MATERIAL USED <b>N/A</b>		LENGTH OF BACK FILLED BORE HOLE <b>N/A</b>		Depth to Top of Primary Filter Pack <b>21'</b>		Depth to Top of the Screen <b>23'</b>
STATIC WATER LEVEL <b>12'</b>	FEET FROM MEASURING POINT		MULTIPLE CASING WELLS SUBMIT ADDITIONAL AS BUILT DIAGRAM SHOWING WELL CONSTRUCTION DETAILS INCLUDING TYPE AND SIZE OF ALL CASING, HOLE DIAMETERS, AND GROUT USED.		MEASURING POINT FOR STATIC WATER LEVEL IS <input checked="" type="checkbox"/> TOP OF RISER PIPE <input type="checkbox"/> OTHER		Depth to Bottom of the Screen <b>38'</b>
DATE OF STATIC WATER LEVEL <b>7-23-96</b>	MEASURING POINT FOR STATIC WATER LEVEL IS <input checked="" type="checkbox"/> TOP OF RISER PIPE <input type="checkbox"/> OTHER		DRILLING EQUIPMENT <input type="checkbox"/> AIR ROTARY <input checked="" type="checkbox"/> AUGER TYPE <b>Hand-dug</b>		ELEVATION OF MEASURING POINT <b>N/A</b>		DATE WELL DRILLING WAS COMPLETED <b>7-23-96</b>

I HEREBY CERTIFY THAT THE MONITORING WELL HEREIN DESCRIBED WAS CONSTRUCTED IN ACCORDANCE WITH THE DEPARTMENT OF NATURAL RESOURCES REQUIREMENTS FOR THE CONSTRUCTION OF MONITORING WELLS.

SIGNATURE PRIMARY CONTRACTOR/PERMIT <b>Charley Roberts</b>	DATE <b>8-27-96</b>	SIGNATURE DRILLER/PERMIT <b>Charley Roberts</b>	DATE <b>8-27-96</b>
---	------------------------	--	------------------------

MO 700-1415 (3-95)

DISTRIBUTION: WHITE/DIVISION CANARY/MONITORING WELL CONTRACTOR PINK/OWNER  
MAIL WHITE COPY TO: DEPARTMENT OF NATURAL RESOURCES, P.O. BOX 250, ROLLA, MO 65407  
ENCLOSE \$35 PER MONITORING WELL FOR THE CERTIFICATION FEE WITHIN 60 DAYS AFTER WELL COMPLETION



MISSOURI DEPARTMENT OF  
NATURAL RESOURCES  
DIVISION OF GEOLOGY AND  
LAND SURVEY  
REGISTRATION RECORD

OFFICE USE ONLY

REF. NO. 114868  
ROUTE PCO  
STATE WELL NUMBER 800675  
CHECKED BY KT  
APPROVED BY

DATE RECEIVED  
RECEIVED JAN 23 1995  
CHECK 1534101010  
TRANSMITTAL NUMBER 75979  
CROSS REFERENCE NO.  
ENTERED  
DATE APPROVED

INFORMATION SUPPLIED BY OWNER

NAME Mr. Joseph K. Russ, P.E. %Board of Public Service, City of St. Louis  
TELEPHONE 314-622-3535  
ADDRESS City Hall, Room 305  
1200 Market St.  
CITY St. Louis  
STATE MO ZIP CODE 63103  
ADDRESS OF WELL SITE (IF DIFFERENT THAN ABOVE)  
7600 Halls Street  
CITY St. Louis  
STATE MO ZIP CODE 63146  
OWNER STATUS  
☐ PRIVATE HOME OWNER ☐ BUILDER ☐ DEVELOPER ☒ OTHER (SPECIFY) city of St. Louis  
PURPOSE OF REGISTRATION FORM  
☐ ABANDONED WELL ☒ TEST HOLE REPORT  
☐ WELL RECONSTRUCTION ☐ OTHER  
EXISTING WELL CERTIFICATION NUMBER  
DATE COMPLETED  
SIGNATURE (WELL OWNER) DATE

INFORMATION SUPPLIED BY CONTRACTOR

LOCATION OF WELL  
SHOW LOCATION IN SECTION PLAT  
COUNTY St. Louis  
ELEVATION  
AREA NO. 1  
SMALLEST 1/4 SW 1/4 NE 1/4 SW 1/4 SE 1/4  
SEC. 20 TWN. 46 N. R. 7 E. COR. W.  
LAT. 38 40 LONG. 90 10  
SKETCH THE LOCATION TO THE WELL INCLUDING MILEAGE ON ALL ROADS TRAVELED FROM NEAREST TOWN OR HIGHWAY  
3.5 miles  
1.5 miles  
Halls St  
Grand Blvd  
Missouri River

DESCRIBE LOCATION OF THE WELL, SO WE WOULD BE ABLE TO VISIT THE WELL  
HWY 40 E-go East (right) on Grand Blvd.-go North (left) on Hall Street.  
Boreholes are located in the front of the facility.

CONTRACTOR'S NAME ELLIS A. SHIBLEE  
% GEO ENVIRONMENTAL SERVICES, INC.  
PERMIT NUMBER 001746M

ABANDONMENT OF WELLS WELL RECONSTRUCTION

DEPTH OF THE WELL SB1 thru SB15  
14.0' each  
DATE ABANDONED 8/15-16/94  
TYPE OF REPAIR  
☐ RAISED CASING ☐ LINING OF WELL  
☐ DEEPENING OF WELL ☐ OTHER

FORMER USE OF WELL  
☐ DOMESTIC (1 TO 3 CONNECTIONS) ☐ PUBLIC WATER SUPPLY  
☐ MULTI-FAMILY ☒ EXPLORATORY TEST HOLE  
☐ HEAT PUMP ☐ MONITORING  
☐ IRRIGATION ☐ OTHER  
RAISED CASING INFORMATION  
LENGTH OF CASING ADDED FT.  
METHOD OF ATTACHMENT  
STEEL CASING ☐ THREADED ☐ WELDED ☐ COUPLED  
PLASTIC CASING ☐ USED ☐ GLUED

DATE ORIGINALLY DRILLED 8/15-16/94  
PUMP REMOVED FROM WELL? ☐ YES ☐ NO  
ORIGINAL DRILLER (IF KNOWN)  
Roberts Environmental Drilling, Inc.  
LINER DETAILS  
PURPOSE OF LINER  
☐ USED ONLY TO HOLD BACK FORMATION  
☐ USED TO SEAL OUT CONTAMINATION OR OTHER CONDITIONS  
DIAMETER OF LINER IN.  
WEIGHT OR SOR #

DESCRIBE METHOD USED TO PLUG WELL  
Grouted via tremie with cement slurry to within 2' of ground surface. Top 2' filled with bentonite pellets and hydrated every 8".  
MEASURED DEPTH FROM SURFACE TO THE TOP OF LINER FT.  
MEASURED DEPTH FROM SURFACE TO BOTTOM OF LINER FT.  
DIAMETER OF WELL CASING IN.  
MATERIAL ☐ PLASTIC ☐ STEEL  
JOINTS ☐ GLUED ☐ THREADED ☐ WELDED

COMMENTS (REASON FOR PLUGGING, KNOWN CONTAMINANTS, ETC.)  
All 15 borings were exploratory test holes.  
Indication of slight petroleum hydrocarbon contaminants thru field Hsu readings.  
LINER PACKER DETAILS  
TYPE USED ☐ NONE ☐ RUBBER BOOT  
POSITION OF SEAL ☐ FULL LENGTH ☐ BETWEEN PACKERS  
MATERIAL ☐ CEMENT SLURRY ☐ BENTONITE ☐ CHIPS ☐ GRANULATED ☐ PELLETS  
DEPTH PUMP WAS SET FT.  
DEPTH FROM SURFACE TO TOP OF THE GROUT SEAL FT.  
DEPTH FROM SURFACE TO BOTTOM OF THE GROUT SEAL FT.

WAS THE WELL ABANDONED BECAUSE OF HOOKING UP TO A PUBLIC OR RURAL WATER SUPPLY DISTRICT?  
☐ YES ☒ NO  
CHECK THE BOX WHICH APPLIES  
☒ I HEREBY CERTIFY THAT THE WELL HEREIN DESCRIBED WAS ABANDONED IN ACCORDANCE WITH THE DEPARTMENT OF NATURAL RESOURCES REQUIREMENTS FOR THE ABANDONMENT OF WELLS.  
☐ I HEREBY CERTIFY THAT THE WELL HEREIN DESCRIBED WAS REPAIRED IN ACCORDANCE WITH THE DEPARTMENT OF NATURAL RESOURCES REQUIREMENTS FOR THE REPAIR OF WELLS.  
CONTRACTOR'S SIGNATURE Ellis A. Shiblee  
DATE 12-19-94

DEEPENING OF WELL INFORMATION  
WELL WAS DEEPENED  
FROM FT. DEEP  
TO FT. DEEP  
WAS THE WELL DISINFECTED?  
☐ YES ☐ NO  
DEPTH  
FORMATION DESCRIPTION  
YIELD



MISSOURI DEPARTMENT OF  
NATURAL RESOURCES  
DIVISION OF GEOLOGY AND  
LAND SURVEY  
**REGISTRATION RECORD**

OFFICE USE ONLY

REF. NO. <b>123145</b>	CHECK NO. <b>1054</b>	DATE RECEIVED <b>1054</b>
ROUTE <b>P-0</b>	TRANS. NO. <b>1883974</b>	DATE <b>1054</b>
STATE WELL NUMBER <b>800693</b>	CROSS-REFERENCE NO.	ENTERED
CHECKED BY <b>KY</b>	ENTERED	DATE APPROVED
APPROVED BY	DATE APPROVED	

**INFORMATION SUPPLIED BY OWNER**

NAME <b>Allied Services Division Severance Fund</b>		TELEPHONE <b>708-297-0040</b>	
ADDRESS <b>3113 West Old Higgins Road</b>	CITY <b>ELK Grove Village</b>	STATE <b>IL</b>	ZIP CODE <b>60007</b>
ADDRESS OF WELL SITE (IF DIFFERENT THAN ABOVE) <b>4317 Jennings Station Areal</b>	CITY <b>St. Louis</b>	STATE <b>MO</b>	ZIP CODE <b>63121</b>
OWNER STATUS <input type="checkbox"/> PRIVATE HOME OWNER <input type="checkbox"/> BUILDER <input type="checkbox"/> DEVELOPER <input checked="" type="checkbox"/> OTHER (SPECIFY) <b>Business Owner</b>			
PURPOSE OF REGISTRATION FORM <input type="checkbox"/> ABANDONED WELL <input checked="" type="checkbox"/> TEST HOLE REPORT <input type="checkbox"/> WELL RECONSTRUCTION <input checked="" type="checkbox"/> OTHER <b>Geo-Probe Test holes</b>		EXISTING WELL CERTIFICATION NUMBER <b>N/A - No wells</b> DATE COMPLETED	
		SIGNATURE (WELL OWNER) _____ DATE	

**INFORMATION SUPPLIED BY CONTRACTOR**

LOCATION OF WELL SHOW LOCATION IN SECTION PLAT		COUNTY <b>St. Louis</b>	SKETCH THE LOCATION TO THE WELL INCLUDING MILEAGE ON ALL ROADS TRAVELED FROM NEAREST TOWN OR HIGHWAY
ELEVATION _____ AREA NO. <b>4</b>			



MISSOURI DEPARTMENT OF  
NATURAL RESOURCES  
DIVISION OF GEOLOGY AND  
LAND SURVEY  
**REGISTRATION RECORD**

OFFICE USE ONLY

REF. NO. **129101**

RECEIVED APR 20 1995

ROUTE **WEG** **PCD**

# W.S. NUMBER

CHECK NUMBER

STATE WELL NUMBER **BD1757**

TRANSMITTAL NO.

CHECKED BY **KT**

CROSS REFERENCE NO.

APPROVED BY

DATE

ENTERED

PH 1

PH 2

PH 3

**INFORMATION SUPPLIED BY OWNER**

NAME <b>H.B. Fuller Company</b>		Contact Name: <b>David Gisman</b>		TELEPHONE <b>612-481-4881</b>	
ADDRESS <b>4100 Union Boulevard</b>		CITY <b>St. Louis</b>		STATE <b>MO</b>	TWP CODE <b>63115</b>
SITE NAME <b>H.B. Fuller</b>		WELL NUMBER <b>N/A</b>	ADDRESS OF WELL SITE OR SITE NAME IF DIFFERENT THAN ABOVE		
OWNER STATUS: <input type="checkbox"/> BUILDER <input type="checkbox"/> PRIVATE HOME OWNER <input type="checkbox"/> DEVELOPER <input checked="" type="checkbox"/> OTHER (SPECIFY) <b>Business</b>		CITY	STATE	ZIP CODE	
PURPOSE OF REGISTRATION FORM <input type="checkbox"/> ABANDONED WELL <input type="checkbox"/> MINERAL EXPLORATORY <input checked="" type="checkbox"/> WELL RECONSTRUCTION <b>TEST HOLE</b> <input checked="" type="checkbox"/> OTHER <b>Geo-Probe Test Holes</b>		VARIANCE ISSUED? <input type="checkbox"/> YES <input type="checkbox"/> NO	VARIANCE NUMBER	WELL CERTIFICATION NUMBER <b>N/A</b>	DATE ORIGINALLY DRILLED
		SIGNATURE (WELL OWNER)		DATE	

**INFORMATION SUPPLIED BY CONTRACTOR**

SKETCH THE LOCATION TO THE WELL INCLUDING NEAREST ROAD OR RAILROAD UNPAVED FROM NEAREST TOWNSHIP OR HIGHWAY 		<b>LOCATION OF WELL</b> SHOW LOCATION IN SECTION PLAT QUAD _____ COUNTY <b>St. Louis</b> ELEV _____ AREA NO. <b>A1</b> SMALLEST W _____ LARGEST W _____ SEC. <b>29</b> TWN. <b>46N.</b> R. <b>7E</b> EORW LAT. _____ LONG. _____	
DISK THE LOCATION OF THE WELL SO WE WOULD BE ABLE TO FIND IT <b>Geo-Probe Test holes - Approx Locations illustrated above</b>			
CONTRACTOR'S NAME <b>Petro-Probe Investigations</b>		PERMIT NUMBER <b>002182</b>	

<b>ABANDONMENT OF WELLS</b> <input type="checkbox"/> OTHER USE OF WELL <input type="checkbox"/> HAND DUG <input checked="" type="checkbox"/> SOIL BORING <input type="checkbox"/> DOMESTIC (1 TO 3 CONNECTIONS) <input type="checkbox"/> PUBLIC WATER SUPPLY <input type="checkbox"/> MULTI-FAMILY <input type="checkbox"/> MINERAL EXPLORATORY TEST HOLE <input type="checkbox"/> HEAT PUMP <input type="checkbox"/> MONITORING <input type="checkbox"/> IRRIGATION <input type="checkbox"/> OTHER ORIGINAL DRILLER (IF KNOWN) <b>N/A</b> DATE ORIGINALLY DRILLED <b>3-14-95</b>		<b>WELL RECONSTRUCTION</b> TYPE OF REPAIR <input type="checkbox"/> RAISED CASING <input type="checkbox"/> LINING OF WELL <input type="checkbox"/> DEEPENING OF WELL <input type="checkbox"/> OTHER USE OF WELL <input type="checkbox"/> DOMESTIC (1 TO 3 CONNECTIONS) <input type="checkbox"/> PUBLIC WATER SUPPLY <input type="checkbox"/> MULTI-FAMILY <input type="checkbox"/> MONITORING <input type="checkbox"/> HEAT PUMP <input type="checkbox"/> OTHER IRRIGATION	
DATE PLUGGED <b>3-16-95</b>	STATIC WATER LEVEL <b>N/A</b> FT.	PUMP REMOVED FROM WELL? <input type="checkbox"/> YES <input type="checkbox"/> NO	DIA. OF WELL CASING IN. <input type="checkbox"/> YES <input type="checkbox"/> NO
DEPTH OF THE WELL (FT.) <b>20 max</b>	LENGTH OF CASING	CASING DIAMETER/WELL DIA. <b>1.5</b>	DATE RECONSTRUCTION COMPLETED
GROUT INSTALLATION METHOD <input checked="" type="checkbox"/> GRAVITY <input type="checkbox"/> TREMIE <input type="checkbox"/> YES <input type="checkbox"/> NO	CASING CUT OFF THREE FEET BELOW SURFACE?	TYPE OF CASING <input type="checkbox"/> STEEL <input type="checkbox"/> PLASTIC <input type="checkbox"/> OTHER	RAISED CASING INFORMATION
GROUT MATERIAL USED NEAT CEMENT <input type="checkbox"/> BENTONITE SLURRY <input type="checkbox"/> PORTLAND TYPE I <input type="checkbox"/> OTHER <input type="checkbox"/>	BENTONITE <input type="checkbox"/> FLOUNDER <input checked="" type="checkbox"/> GRANULAR <input type="checkbox"/> CHIPS <input type="checkbox"/> PELLETS	NUMBER OF BAGS OF GROUT USED <b>3</b>	POUNDS OF GROUT PER BAG <b>50</b>
IF NEAT CEMENT USED, HOW MANY GALLONS OF WATER MIXED PER BAG OF CEMENT		DIA. OF WELL CASING	
TYPE OF FILL MATERIAL USED		WAS WELL DISINFECTED AFTER RECONSTRUCTION IN. <input type="checkbox"/> YES <input type="checkbox"/> NO	
AMOUNT OF FILL MATERIAL USED CU. YDS.		LENGTH OF CASING ADDED FT.	
DEPTH TO TOP OF FILL MATERIAL		MATERIAL <input type="checkbox"/> STEEL <input type="checkbox"/> PLASTIC	
WELL DISINFECTED BEFORE PLUGGING? <input type="checkbox"/> YES <input type="checkbox"/> NO		METHOD OF ATTACHMENT <input type="checkbox"/> THREADED <input type="checkbox"/> FUSED <input type="checkbox"/> WELDED <input type="checkbox"/> GLUED <input type="checkbox"/> COUPLED	
NUMBER USED FOR DISINFECTION GALLONS OF CHLORINE POUNDS OF CHLORINE TABLETS OF CHLORINE		PURPOSE OF LINER <input type="checkbox"/> USED ONLY TO HOLD BACK FORMATION <input type="checkbox"/> USED TO SEAL OUT CONTAMINATION OR OTHER CONDITIONS	
WAS THE WELL ABANDONED BECAUSE OF HOOKING UP TO A PUBLIC OR RURAL WATER SUPPLY DISTRICT? <input type="checkbox"/> YES <input type="checkbox"/> NO		LINER DETAILS DEPTH TO THE TOP OF LINER FROM SURFACE FT. <input type="checkbox"/> PLASTIC <input type="checkbox"/> STEEL	
IF YES, WHAT IS THE NAME OF THE WATER DISTRICT?		AMOUNT OF LINER USED FT.	
CHECK THE BOX WHICH APPLIES <input checked="" type="checkbox"/> <b>Test Holes</b> <input type="checkbox"/>		JOINTS <input type="checkbox"/> GLUED <input type="checkbox"/> WELDED <input type="checkbox"/> OTHER	
I HEREBY CERTIFY THAT THE WELL HEREIN DESCRIBED WAS ABANDONED IN ACCORDANCE WITH THE DEPARTMENT OF NATURAL RESOURCES REQUIREMENTS FOR THE ABANDONMENT OF WELLS.		LINER PACKER DETAILS TYPE USED <input type="checkbox"/> NONE <input type="checkbox"/> RUBBER BOOT	
I HEREBY CERTIFY THAT THE WELL HEREIN DESCRIBED WAS REPAIRED IN ACCORDANCE WITH THE DEPARTMENT OF NATURAL RESOURCES REQUIREMENTS FOR THE REPAIR OF WELLS.		POSITION OF SEAL <input type="checkbox"/> FULL LENGTH <input type="checkbox"/> BETWEEN PACKERS	
CONTRACTOR'S SIGNATURE 		MATERIAL CEMENT: <input type="checkbox"/> PORTLAND TYPE I <input type="checkbox"/> HEAVY BENTONITE <input type="checkbox"/> CHIPS <input type="checkbox"/> PELLETS <input type="checkbox"/> GRANULAR	
DATE <b>4-24-95</b>		DEPTH FROM SURFACE TO TOP OF THE GROUT SEAL FT.	
		DEPTH FROM SURFACE TO BOTTOM OF THE GROUT SEAL FT.	
		GPM	
		DEEPENING OF WELL INFORMATION	
		FORMATION DESCRIPTION	
		YIELD	

MO 795-1614 (11-90)

DISTRIBUTION: WHITE/CONTRACTOR CANARY/DIVISION PINK/OWNER

MAIL CANARY COPY TO DEPARTMENT OF NATURAL RESOURCES, P.O. BOX 250, ROLLA, MO 65401

RECORD MUST BE SUBMITTED WITHIN 90 DAYS OF COMPLETION DATE



MISSOURI DEPARTMENT OF  
NATURAL RESOURCES  
DIVISION OF GEOLOGY AND  
LAND SURVEY  
REGISTRATION RECORD

OFFICE USE ONLY

REF. NO. 132866

DATE RECEIVED

RECEIVED OCT 27 1997

ROUTE PCO

P.W.B. NUMBER

CHECK NUMBER

STATE WELL NUMBER 203798

TRANSMITTAL NO.

CHECKED BY [Signature]

COORD. REFERENCE NO.

APPROVED BY

DATE

ENTERED

PH 1

PH 2

PH 3

INFORMATION SUPPLIED BY OWNER

NAME: Morris Auto Repair - Howard Morris		TELEPHONE: (314) 385-9450	
ADDRESS: 4422 Lindbergh Blvd. ST. LOUIS		STATE: MO	ZIP CODE: 63120
SITE NAME: Morris Auto Repair	WELL NUMBER:	ADDRESS OF WELL SITE OR SITE NAME IF DIFFERENT THAN ABOVE: A.C.	
OWNER STATUS: <input type="checkbox"/> BUILDER <input type="checkbox"/> PRIVATE HOME OWNER <input type="checkbox"/> DEVELOPER <input checked="" type="checkbox"/> OTHER (SPECIFY) BUSINESS	CITY:	STATE:	ZIP CODE:
PURPOSE OF REGISTRATION FORM: <input type="checkbox"/> ABANDONED WELL <input type="checkbox"/> MINERAL EXPLORATORY <input type="checkbox"/> WELL RECONSTRUCTION TEST HOLE <input checked="" type="checkbox"/> OTHER: See attached drilling plan	VARIANCE ISSUED? <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO	VARIANCE NUMBER:	WELL CERTIFICATION NUMBER: DATE ORIGINALLY DRILLED:
SIGNATURE (WELL OWNER):		DATE:	

INFORMATION SUPPLIED BY CONTRACTOR

SKETCH THE LOCATION TO THE WELL INCLUDING MILEAGE ON ALL ROADS TRAVELED FROM NEAREST TOWNS OR HIGHWAYS 		LOCATION OF WELL SHOW LOCATION IN SECTION PLAT QUAD: CLAYTON COUNTY: ST. LOUIS ELEV: AREA NO.: SMALLEST: 3 LARGEST: 7 SEC. 31 TWN. 46. N. RANG. 7 E. OR W. LAT. 38. 41. 11.60 LONG. 90. 46. 41.60	
DESCRIBE LOCATION OF THE WELL SO WE WOULD BE ABLE TO VISIT THE WELL See attached drilling plan. TOTAL OF DEPTH (2) Drilling location is 300 feet in depth. See attached drilling plan.		CONTRACTOR'S NAME: [Signature] PERMIT NUMBER: [Blank]	
DRILLERS NAME: [Signature] PERMIT NUMBER: [Blank]		DATE: 10-24-97	

ABANDONMENT OF WELLS

WELL RECONSTRUCTION

FURTHER USE OF WELL: <input type="checkbox"/> HAND DIG <input checked="" type="checkbox"/> SOIL BORING <input type="checkbox"/> DOMESTIC (1 TO 3 CONNECTIONS) <input type="checkbox"/> PUBLIC WATER SUPPLY <input type="checkbox"/> MULTI-FAMILY <input checked="" type="checkbox"/> MINERAL EXPLORATORY TEST HOLE <input type="checkbox"/> HEAT PUMP <input type="checkbox"/> MONITORING <input type="checkbox"/> IRRIGATION <input type="checkbox"/> OTHER:		TYPE OF REPAIR: <input type="checkbox"/> RAISED CASING <input type="checkbox"/> LINING OF WELL <input type="checkbox"/> DEEPENING OF WELL <input type="checkbox"/> OTHER:	
ORIGINAL DEPTH (IF KNOWN): 10-10-97		DATE RECONSTRUCTION COMPLETED:	
DATE PLUGGED: 10-10-97	STATIC WATER LEVEL: FT.	PLUG REMOVED FROM WELL? <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO	DATE RECONSTRUCTION COMPLETED:
DEPTH OF THE WELL: 30 feet	LENGTH OF CASING: 310	CASING DIAMETER WELL DIA: 310	DATE RECONSTRUCTION COMPLETED:
GROUT INSTALLATION METHOD: <input checked="" type="checkbox"/> GRAVITY <input type="checkbox"/> TREMIE <input type="checkbox"/> YES <input type="checkbox"/> NO	CASING CUT OFF THREE FEET BELOW SURFACE	TYPE OF CASING: <input type="checkbox"/> STEEL <input type="checkbox"/> PLASTIC <input type="checkbox"/> OTHER:	RAISED CASING INFORMATION:
GROUT MATERIAL USED: HEAT CEMENT <input type="checkbox"/> BENTONITE SLURRY <input type="checkbox"/> PORTLAND TYPE 1 <input type="checkbox"/> OTHER:	BENTONITE: <input type="checkbox"/> POWDER <input type="checkbox"/> GRANULAR <input type="checkbox"/> CHIPS <input type="checkbox"/> PELLETS	NUMBER OF BAGS OF GROUT USED: 50	LINEAR DETAILS:
IF HEAT CEMENT USED, HOW MANY GALLONS OF WATER MIXED PER BAG OF CEMENT:		PURPOSE OF LINER: <input type="checkbox"/> USED ONLY TO HOLD BACK FORMATION <input type="checkbox"/> USED TO SEAL OUT CONTAMINATION OR OTHER CONDITIONS	
TYPE OF FILL MATERIAL USED:		MATERIAL: <input type="checkbox"/> STEEL <input type="checkbox"/> PLASTIC	
AMOUNT OF FILL MATERIAL USED: CU. YDS.		METHOD OF ATTACHMENT: <input type="checkbox"/> INTERLOCKED <input type="checkbox"/> FLUSH <input type="checkbox"/> WELDED <input type="checkbox"/> GRIFF <input type="checkbox"/> COUPLED	
DEPTH TO TOP OF FILL MATERIAL:		DEPTH TO THE TOP OF LINER FROM SURFACE: FT. <input type="checkbox"/> PLASTIC <input type="checkbox"/> STEEL	
WELL DISINFECTED BEFORE PLUGGING? <input type="checkbox"/> YES <input type="checkbox"/> NO		AMOUNT OF LINER USED: FT. <input type="checkbox"/> GLUED <input type="checkbox"/> WELDED <input type="checkbox"/> OTHER:	
NUMBER USED FOR DISINFECTION: GALLONS OF CHLORINE: TABLETS OF CHLORINE:		LINER PACKER DETAILS:	
WAS THE WELL ABANDONED BECAUSE OF LOOKING UP TO A PUBLIC OR RURAL WATER SUPPLY DISTRICT? <input type="checkbox"/> YES <input type="checkbox"/> NO		POSITION OF SEAL: <input type="checkbox"/> FULL LENGTH <input type="checkbox"/> BETWEEN PACKERS	
IF YES, WHAT IS THE NAME OF THE WATER DISTRICT:		MATERIAL: CEMENT: <input type="checkbox"/> PORTLAND TYPE 1 <input type="checkbox"/> READY MIXED <input type="checkbox"/> OTHER: BENTONITE: <input type="checkbox"/> CHIPS <input type="checkbox"/> SLURRY <input type="checkbox"/> GRANULAR	
CHECK THE BOX WHICH APPLIES: <input checked="" type="checkbox"/> TEST HOLE <input type="checkbox"/> I HEREBY CERTIFY THAT THE WELL HEREIN DESCRIBED WAS ABANDONED IN ACCORDANCE WITH THE DEPARTMENT OF NATURAL RESOURCES REQUIREMENTS FOR THE ABANDONMENT OF WELLS		DEPTH PUMP WAS SET: FT. GPM: DEPTH FROM SURFACE TO TOP OF THE GROUT SEAL: FT. DEPTH FROM SURFACE TO BOTTOM OF THE GROUT SEAL: FT.	
CONTRACTOR'S SIGNATURE: [Signature]		DEEPENING OF WELL INFORMATION:	
DATE: 10-24-97		FORMATION DESCRIPTION: YIELD:	

MO TR-1114 (1-95)

DISTRIBUTION: WHITE/CONTRACTOR CANARY/DIVISION PINK/OWNER

MAIL CANARY COPY TO: DEPARTMENT OF NATURAL RESOURCES, P.O. BOX 200, ROLLA, MO 65401 RECORD MUST BE SUBMITTED WITHIN 60 DAYS OF COMPLETION DATE





MISSOURI DEPARTMENT OF  
NATURAL RESOURCES  
DIVISION OF GEOLOGY AND  
LAND SURVEY  
**REGISTRATION RECORD**

OFFICE USE ONLY

REF. NO. **152450**

RECEIVED AUG 30 1996

ROUTE <b>RD</b>	F.W.E. NUMBER	CHECK NUMBER
STATE WELL NUMBER <b>RD 2377</b>	TRANSMITTAL NO.	
CHECKED BY <b>RT</b>	CROSS REFERENCE NO.	
APPROVED BY	DATE	ENTERED PR 1 <input checked="" type="checkbox"/> PR 2 <input checked="" type="checkbox"/> PR 3 <input checked="" type="checkbox"/>

**INFORMATION SUPPLIED BY OWNER**

NAME <b>ABB Combustion Engineering</b>		TELEPHONE <b>314/296-5640</b>	
ADDRESS <b>3300 State Road P</b>		CITY <b>Henrieville</b>	STATE <b>MO</b>
ZIP CODE <b>63047</b>			
WELL NAME <b>ABB Fuels</b>	WELL NUMBER <b>RMC 13</b>	ADDRESS OF WELL SITE OR SITE NAME IF DIFFERENT THAN ABOVE	
OWNER STATUS <input type="checkbox"/> BUILDER <input type="checkbox"/> PRIVATE HOME OWNER <input type="checkbox"/> DEVELOPER <input checked="" type="checkbox"/> OTHER (SPECIFY)	CITY	STATE	ZIP CODE
PURPOSE OF REGISTRATION FORM <input checked="" type="checkbox"/> ABANDONED WELL <input type="checkbox"/> MINERAL EXPLORATORY <input type="checkbox"/> WELL RECONSTRUCTION TEST HOLE <input checked="" type="checkbox"/> OTHER <b>PVC TUBES</b>			
VARIANCE ISSUED? <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO	VARIANCE NUMBER	WELL CERTIFICATION NUMBER <b>N/A</b>	DATE ORIGINALLY DRILLED <b>N/A</b>
SIGNATURE (WELL OWNER) <i>Charles Roberts</i>		DATE <b>8/27/96</b>	

**INFORMATION SUPPLIED BY CONTRACTOR**

SKETCH THE LOCATION TO THE WELL INCLUDING MILEAGE ON ALL ROADS TRAVELED FROM NEAREST TOWN OR HIGHWAYS		<b>LOCATION OF WELL</b> SHOW LOCATION IN SECTION PLAT QUAD <b>Pestus</b> COUNTY <b>Jefferson</b> ELEV <b>-</b> AREA NO. <b>1</b>	
		SMALLEST 1/4 <b>-</b> LARGEST 1/4 <b>-</b> SEC. <b>9</b> TWN. <b>40</b> N. RANG. <b>5</b> EDH W LAT. <b>38.12.30</b> LONG. <b>90.29.28</b>	

DESCRIBE LOCATION OF THE WELL SO WE WOULD BE ABLE TO VISIT THE WELL  
**Various locations on East side of Facility**

CONTRACTOR'S NAME <b>Roberts Env. Servicing</b>	PERMIT NUMBER <b>001148 WPM</b>	DRILLER'S NAME <b>Roberts Env. Servicing</b>	PERMIT NUMBER <b>001142 M</b>
<b>Charles Roberts</b>		<b>J. M. PARKER</b>	

<b>ABANDONMENT OF WELLS</b>		<b>WELL RECONSTRUCTION</b>	
FORMER USE OF WELL <b>PVC Tubes - NO 5" SIZES</b> <input type="checkbox"/> HAND DUG <input type="checkbox"/> SOIL BORING <input checked="" type="checkbox"/> DOMESTIC (1 TO 3 CONNECTIONS) <input type="checkbox"/> PUBLIC WATER SUPPLY <input type="checkbox"/> MULTI-FAMILY <input type="checkbox"/> MINERAL EXPLORATORY TEST HOLE <input type="checkbox"/> HEAT PUMP <input type="checkbox"/> MONITORING <input type="checkbox"/> IRRIGATION <input checked="" type="checkbox"/> OTHER <b>check radiological</b>		TYPE OF REPAIR <input type="checkbox"/> RAISED CASING <input checked="" type="checkbox"/> LINING OF WELL <input checked="" type="checkbox"/> DEEPENING OF WELL <input type="checkbox"/> OTHER USE OF WELL <input type="checkbox"/> DOMESTIC (1 TO 3 CONNECTIONS) <input type="checkbox"/> PUBLIC WATER SUPPLY <input type="checkbox"/> MULTI-FAMILY <input type="checkbox"/> MONITORING <input type="checkbox"/> HEAT PUMP <input type="checkbox"/> OTHER <input type="checkbox"/> IRRIGATION	
DATE PLUGGED <b>8/26/96</b>	STATIC WATER LEVEL <b>6</b> FT	PUMP REMOVED FROM WELL? <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO	DATE RECONSTRUCTION COMPLETED
DEPTH OF THE WELL <b>19.1</b>	LENGTH OF CASING <b>19.1</b>	CASING DIA. <b>4"</b> MOLE DIA. <b>4 1/2"</b>	LENGTH OF CASING ADDED FT.
GRAVITY <input checked="" type="checkbox"/> TREMIE <input type="checkbox"/>	CASING CUT OFF THREE FEET BELOW SURFACE	TYPE OF CASING <input type="checkbox"/> STEEL <input checked="" type="checkbox"/> PLASTIC <input type="checkbox"/> OTHER	RAISED CASING INFORMATION
GROUT MATERIAL USED <input checked="" type="checkbox"/> BENTONITE <input type="checkbox"/> POWDER <input type="checkbox"/> GRANULAR <input type="checkbox"/> HEAVY CEMENT <input type="checkbox"/> SLURRY <input checked="" type="checkbox"/> CHIPS <input type="checkbox"/> FELLETS <input type="checkbox"/> PORTLAND TYPE 1 <input type="checkbox"/> OTHER	NUMBER OF BAGS OF GROUT USED <b>4</b>	FOUNDS OF GROUT PER BAG <b>50</b>	LINER DETAILS
HOW MANY GALLONS WATER MIXED PER BAG OF CEMENT OR BENTONITE? <b>N/A</b>	TYPE OF FILL MATERIAL USED <b>Bentonite chips</b>	AMOUNT OF FILL MATERIAL USED <b>250 lbs</b>	DEPTH TO THE TOP OF LINER FROM SURFACE FT.
DEPTH TO TOP OF FILL MATERIAL FROM SURFACE <b>N/A</b>	WELL DISINFECTED BEFORE PLUGGING? <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO	NUMBER USED FOR DISINFECTION GALLONS OF CHLORINE TABLETS OF CHLORINE	AMOUNT OF LINER USED FT.
WAS THE WELL ABANDONED BECAUSE OF HOOKING UP TO A PUBLIC OR RURAL WATER SUPPLY DISTRICT? <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO	IF YES, WHAT IS THE NAME OF THE WATER DISTRICT?	DEPTH PUMP WAS SET GPM	DEPTH FROM SURFACE TO TOP OF THE GROUT SEAL FT.
<b>CHECK THE BOX WHICH APPLIES</b>		<b>DEEPENING OF WELL INFORMATION</b>	
<input checked="" type="checkbox"/> I HEREBY CERTIFY THAT THE WELL HEREIN DESCRIBED WAS ABANDONED IN ACCORDANCE WITH THE DEPARTMENT OF NATURAL RESOURCES REQUIREMENTS FOR THE ABANDONMENT OF WELLS. CONTRACTOR'S SIGNATURE <b>Charles Roberts</b> DATE <b>8/27/96</b>		<input type="checkbox"/> I HEREBY CERTIFY THAT THE WELL HEREIN DESCRIBED WAS REPAIRED IN ACCORDANCE WITH THE DEPARTMENT OF NATURAL RESOURCES REQUIREMENTS FOR THE REPAIR OF WELLS. FORMATION DESCRIPTION FIELD	

MD 780-1414 (11-95)

DISTRIBUTION: WHITE/CONTRACTOR CANARY/DIVISION PINK/OWNER

MAIL CANARY COPY TO: DEPARTMENT OF NATURAL RESOURCES, P.O. BOX 250, ROLLA, MO 65402

RECORD MUST BE SUBMITTED WITHIN 60 DAYS OF COMPLETION DATE



MISSOURI DEPARTMENT OF  
NATURAL RESOURCES  
DIVISION OF GEOLOGY AND  
LAND SURVEY  
REGISTRATION RECORD

OFFICE USE ONLY		RECEIVED APR 1 1998	
INT. NO.	183839		
ROUTE	PCD	P.W.S. MAINT.	CHECK NUMBER
STATE WELL NUMBER	604451	TRANSMITTAL NO.	
CHECKED BY	<i>[Signature]</i>	CROSS REFERENCE NO.	
APPROVED BY	DATE	ENTERED	PH 1 PH 2 PH 3

INFORMATION SUPPLIED BY OWNER				B-723	
NAME		MR. SCOTT JEPSEN		TELEPHONE	
ADDRESS		6425 WEST FLORISSANT AVE		314-385-4600	
CITY		ST. LOUIS		STATE	
CITY NAME		STOUT		ZIP CODE	
WELL NUMBER		1 THRU 26		63136	
ADDRESS OF WELL SITE OR SITE NAME IF DIFFERENT THAN ABOVE		5816-5841 HAMILTON AVE		STATE	
OWNER STATUS		PRIVATE HOME OWNER		ZIP CODE	
PURPOSE OF REGISTRATION FORM		FIELD SCREENING		63136	
VARIANCE ISSUED?		NO		DATE ORIGINALLY DRILLED	
SIGNATURE (WELL OWNER)		<i>[Signature]</i>		1/22/98 THRU 2/3/98	

INFORMATION SUPPLIED BY CONTRACTOR	
LOCATION OF WELL	
SHOW LOCATION IN SECTION	
COUNTY ST. LOUIS	
AREA NO.	
SMALLEST 1/4	
SW SW SW NE	
SEC. 20 TWN. 146 N. R. 7	
LAT. LONG.	

CONTRACTOR'S NAME		ENVIRONMENTAL OPERATIONS		PERMIT NUMBER	
DRILLER'S NAME		Scott McEnty		00121717	

ABANDONMENT OF WELLS		WELL RECONSTRUCTION	
TYPE OF WELL		TYPE OF REPAIR	
HAND DUG		RAISED CASING	
DOMESTIC (1 TO 3 CONNECTIONS)		DEEPENING OF WELL	
MULTI-FAMILY		LINING OF WELL	
HEAT PUMP		OTHER	
IRRIGATION		USE OF WELL	
ORIGINAL DRILLER (IF KNOWN)		DOMESTIC (1 TO 3 CONNECTIONS)	
DATE PLUGGED		PUBLIC WATER SUPPLY	
1/27-2/3/98		MONITORING	
DEPTH OF THE WELL		OTHER	
15'		DATE ORIGINALLY DRILLED	
LENGTH OF CASING		1/22 THRU 2/3/98	
CASING DIA.		DIA. OF WELL CASING	
8 1/4"		WAS WELL DISINFECTED AFTER RECONSTRUCTION	
TYPE OF CASING		IN. YES NO	
STEEL PLASTIC		DATE RECONSTRUCTION COMPLETED	
OTHER		LENGTH OF CASING ADDED	
GRAVITY TREMIE		MATERIAL	
YES NO		STEEL	
GROUT MATERIAL USED		PLASTIC	
HEAT CEMENT		METHOD OF ATTACHMENT	
HEAVILY		THREADED	
BENTONITE SLURRY		WELDED	
PORTLAND TYPE 1		COUPLED	
OTHER		DIA. OF LINER	
BENTONITE POWDER		IN.	
GRANULAR		WEIGHT OR LBS.	
CHIPS		PURPOSE OF LINER	
PELLETS		USED ONLY TO HOLD BACK FORMATION	
NUMBER OF BAGS OF GROUT USED		USED TO SEAL OUT CONTAMINATION OR OTHER CONDITIONS	
65		DEPTH TO THE TOP OF LINER FROM SURFACE	
POUNDS OF GROUT PER BAG		FT.	
5.7		MATERIAL	
HOW MANY GALLONS WATER MIXED FOR BAG OF CEMENT OR BENTONITE?		PLASTIC STEEL	
4.8		AMOUNT OF LINER USED	
TYPE OF FILL MATERIAL USED		JOINTS	
AMOUNT OF FILL MATERIAL USED		GLUED WELDED	
CU. YDS./TONS.		FT. OTHER	
DEPTH TO TOP OF FILL MATERIAL FROM SURFACE		LINER PACKER DETAILS	
WELL DISINFECTED BEFORE PLUGGING?		TYPE USED	
YES NO		NONE RUBBER FOOT	
NUMBER USED FOR DISINFECTION		POSITION OF SEAL	
GALLONS OF CHLORINE		FULL LENGTH	
POUNDS OF CHLORINE		BETWEEN PACKERS	
TABLETS OF CHLORINE		MATERIAL	
WAS THE WELL ABANDONED BECAUSE OF HOOKING UP TO A PUBLIC OR RURAL WATER SUPPLY DISTRICT?		CEMENT: PORTLAND TYPE 1 HEAVILY BENTONITE CHIPS PELLETS SLURRY GRANULAR	
YES NO		DEPTH PUMP WAS SET	
IF YES, WHAT IS THE NAME OF THE WATER DISTRICT?		DEPTH FROM SURFACE TO TOP OF THE GROUT SEAL	
CHECK THE BOX WHICH APPLIES		DEPTH FROM SURFACE TO BOTTOM OF THE GROUT SEAL	
I HEREBY CERTIFY THAT THE WELL HEREIN DESCRIBED WAS ABANDONED IN ACCORDANCE WITH THE DEPARTMENT OF NATURAL RESOURCES REQUIREMENTS FOR THE ABANDONMENT OF WELLS.		GPM	
I HEREBY CERTIFY THAT THE WELL HEREIN DESCRIBED WAS REPAIRED IN ACCORDANCE WITH THE DEPARTMENT OF NATURAL RESOURCES REQUIREMENTS FOR THE REPAIR OF WELLS.		DEEPENING OF WELL INFORMATION	
CONTRACTOR'S SIGNATURE		FROM TO	
Scott McEnty		FORMATION DESCRIPTION	
DATE		YIELD	
2/5/98			

MO 780-1414 (11-95) DISTRIBUTION: WHITE/CONTRACTOR CANARY/DIVISION PINK/OWNER  
MAIL CANARY COPY TO DEPARTMENT OF NATURAL RESOURCES, P.O. BOX 700, ROLLA, MO 65402 RECORD MUST BE SUBMITTED WITHIN 60 DAYS OF COMPLETION DATE

## DGLS

## DGLS

TOP	BOT	FORMATION NAME	PRIMARY	SECONDARY	MINOR	PRIMARY OCC.	SECONDARY OCC.	MINOR
0	65	NO SAMPLES				0	0	
65	225	MISSISSIPPIAN SYSTEM				0	0	
65	225	MERAMECIAN SERIES				0	0	
65	225	ST LOUIS LIMESTONE	LIMESTONE		DOLOMITE	0	0	
225	225	TOTAL DEPTH				0	0	

DNR

## MISSOURI SAMPLE WELL-LOG LIBRARY

DGLS

LOG NUMBER

005576

OWNER: LARKIN PACKER CO

PLUGGED ☒ CONFIDENTIAL? ☒ RELEASE DATE:

WELL TYPE: Industrial High Capacity Well

DRILLER: FLAMM, E. (FOR T. FLAMM)

DRILL DATE: 193905 PERMIT #:

LOGGER: GROHSKOPF LOGDATE:

TYPE OF LOG: ☒ D ☒ S ☒ SAMPLE SAVED? ☒ N

ELEVATION: 500 BASE: S BEDROCK @ 65 FEET

TOTAL DEPTH: 300 INTERVAL CORED: 0 TO 0

YIELD: 15 DRAWDOWN:

STATIC WATER LEVEL BEFORE: AFTER: 12

MO , COUNTY: ST. LOUIS

SECTION: 01 TOWNSHIP: 45N RANGE 06E

SW of SW of SW

LATITUDE:

LONGITUDE:

QUAD NAME:

OTHER DATABASES:

ID NUMBER:

DATABASE 2:

ID NUMBER:

DATABASE 3:

ID NUMBER

WATER AT:

TLT

TOP FORMATION: STE. GENEVIEVE LIMESTONE

BOTTOM FORMATION: SALEM FORMATION

REMARKS: 6200 MAPLE AVE.

## CONSTRUCTION DATA

DEPTH:	DIAMETER	CASING MATERIAL	DATE PLUGGED:	DATE ABANDONED:
58	8.5			
CASING:	0	0	Plug Depth TOP	0 Plug Depth Bottom
	0	0	GROUTING:	0
	0	I/O: 0		
	0	SIZE HOLE:	8	

PUMP:	Capacity	Pump Type	Set at: Total Dept	Screen Type:	Size:	Length:	Slot:
	0		0 0		0	0	0
Well Treatment:	Type Devised:	Type of Complet	Perforation Interval:	Tube Pressure:			
Oil Production:		Gas Production:	Top:	0			
			Bottom:	0			

Water Analysis:

OPEN FORMATIONS	Top Formation:	STE. GENEVIEVE LIMESTONE
	Bottom Formation:	SALEM FORMATION

LOG NUMBER

005576

## STRATIGRAPHY

TOP	BOT	FORMATION NAME	LITHOLOGY			MINERALS			
			PRIMARY	SECONDARY	MINOR	PRIMARY	OCC.	SECONDAR	OCC. MINOR
0	65	NO SAMPLES					0		0
65	300	MISSISSIPPIAN SYSTEM					0		0
65	300	MERAMECIAN SERIES					0		0
65	85	STE. GENEVIEVE LIMESTONE	LIMESTONE	SAND			0		0
85	255	ST LOUIS LIMESTONE	LIMESTONE	DOLOMITE	CHERT		0		0
255	300	SALEM FORMATION	LIMESTONE	DOLOMITE	CHERT		0		0
300	300	TOTAL DEPTH					0		0

Page 1 of 2

Project No:		County:	St. Louis	Boring No.:	SUMCD-1	Monitor Well No.:	1		
Project Name:	St. Louis Army Ammunition Plant			Surface Elev.:		Completion Depth:	93'05"		
Fed ID No.:		Auger Depth:	33'	Rotary Depth:	N/A				
State Planar Coordinates:	N.	E.		Date:	7/9/99	Start Time:	10:00	Finish Time:	2:00
Borehole Status:	Monitoring Well			Groundwater Depth:		Method:	Hollow stem Auger		
Drilling Equipment:	CME-7S 4" Hollow stem Auger 2' Split Spoon Continuous Sampler			Surface (circle one):	Bare	Grassy	Wooded		
USCS	DESCRIPTION	Depth	SAMPLES						PERSONNEL
			MOIST	Sample No.	Sample Recovery	Lab Anal (Y/N)	N Valves (Blows)	F.I.D. or P.I.D./LEL Readings	
a	SWAC brown very fine grain silt with clay	0							
		1	Dry	2'					2-3-4-5 2.5 p
	light yellowish brown very fine grain clayey silt - low plasticity - no odor	2							(2-4')
		3	Dry	18"					2-3-5-5 2.0 p
m/c	reddish yellow very fine grain clayey silt med to high plasticity	4							(4-6')
		5							2-3-3-4 2.0 p
m/c	light yellowish brown very fine grained, med. plasticity	6							(6-8')
		7	Damp	2'					3-2-3-4 1.0 p
m/c		8							(8-10')
		9							3-2-3-4 1.75 p
		10	Damp	2'					(10-12')
		11							1-1-2-3 1.5 p
m/l		12							(12-14')
		13	moist	2'					1-2-2-3 1.85 p
m/l		14							(14'-16')
		15	wet	2'					1-3-3-10 1.75 p
		16							(16-18')
cl	gray, sand and silt nodules coarse to medium grained light reddish brown very fine grained weathered shale with clay med to high plasticity	17	CMP	2'					3-7-6-8 1.70 p
		18							(18-20')
cl		19		2'					2.0 p
		20							8-3-6-10

## FIELD BORING LOG

Page 2 of 2

Project No.: Soil Boring No.: Logged by:			MOIST	Sample No.	Sample Recovery	Lab Anal (Y/N)	N Valves (Blows)	FID or PID/LEL	REMARKS
USCS	DESCRIPTION	Depth							
									Robert Hill II Dale Meyers Chris Bucks
									Partly Sunny-920 Breezy
CL	Pale Olive very fine grained weathered shale w/clay (soapy surface) nonplastic	21 22 23 24	DRY	2'					(20-22') 5-13-14-25 74.5P (22-24') 5-5-15-26 4.5P (24-26')
CL	Yellow very fine grained weathered shale w/clay	25 26	DRY	2'					12-20-23-23 4.5P (26-28')
CL	Light gray very fine grained silty weathered shale	27 28 29	DRY	2'					6-11-24-36 54.5P (28-30')
CL	Dark gray very fine grained silty weathered shale, iron oxides present	30 31 32	DRY	2'					9-16-22-50 74.5P (30-32')
	(Spoon Refusal)	33		20.5"					16-32-71-156 74.5P (32-34')
	TD @ 33' 20.5" for 110 blows 2 1/2"	34							137.79-110/2 1/2"

## FIELD BORING LOG

Page 1 of 2

Project No.:		County: <u>St. Louis</u>		Boring No.: <u>Sumner 2</u>		Monitor Well No.:			
Project Name: <u>St. Louis Army Ammunition Plant</u>				Surface Elev.:		Completion Depth: <u>22.4</u>			
Fed ID No.:				Auger Depth: <u>21'</u>		Rotary Depth: <u>N/A</u>			
State Planar Coordinates: N. E.				Date: <u>7/9/99</u>		Start Time: <u>3:30</u> Finish Time: <u>8:45</u>			
Borehole Status: <u>Monitoring Well</u>				Groundwater Depth:		Method: <u>Hollow Stem Auger</u>			
Drilling Equipment: <u>CME - 75</u> <u>4" Hollow Stem Auger</u> <u>2" Split Spoon Continuous Sampler</u>				Surface (circle one): <u>Bare</u> Grassy Wooded			PERSONNEL G. Robert Hill II D. Dale Meyer H. Chris Bocks		
				SAMPLES					
USCS	DESCRIPTION	Depth	MOIST	Sample No.	Sample Recovery	Lab Anal (Y/N)	N Valves (Blows)	F.I.D. or P.I.D./LEL Readings	REMARKS
	<del>Bituminous Asphalt</del>	0							<u>4 1/2" Asphalt</u>
	<del>Concrete</del>	1							<u>10" Concrete</u>
GP	<del>Cobble</del>	2							<u>6" Gravel Pack</u>
	<u>yellowish brown</u>	2	<u>slightly damp</u>						<u>(2-4')</u>
	<u>very fine grain</u>	3	<u>damp</u>		18"				<u>5-4-3-3</u>
	<u>clayey silt, soft,</u>	4	<u>DAMP</u>		1'				<u>0.5p (4-6')</u>
ML	<u>med plasticity</u>	5							<u>2-2-3-3</u>
		6							<u>1.25p (6-8')</u>
	<u>Light yellowish</u>	7			2'				<u>2-3-3-6</u>
	<u>brown very fine</u>	8	<u>DAMP</u>						<u>2.0p (8-10')</u>
ML	<u>grained clayey</u>	9			2'				<u>3-3-4-6</u>
	<u>silt, low to</u>	10							<u>2.0p (10-12')</u>
	<u>medium</u>	11			2'				<u>2-4-7-8</u>
	<u>plasticity</u>	12	<u>DAMP</u>						<u>3.3p (12-14')</u>
	<u>firm</u>	13			2'				<u>2-4-2-7</u>
		14							<u>2.25p (14-16')</u>
		15	<u>slightly damp</u>		2'				<u>3-4-7-9</u>
CL	<u>light gray and</u>	16	<u>DAMP</u>						<u>4.25p (16-18')</u>
ML	<u>iron oxides present</u>	17	<u>MOIST</u>		2'				<u>3-6-9-10</u>
		18							<u>7.45p (18-20')</u>
		19	<u>DAMP</u>		2'				<u>3-5-9-10</u>
		20							<u>4.5p</u>



# FIELD BORING LOG

Page 2 of 2

Project No.: Soil Boring No.: <u>SWMNW-2</u> Logged by: <u>Robert Hill II</u>			ITDG: <u>Robert Hill II</u> <u>Dale Meyer</u> <u>Chris Belch</u>						
USCS	DESCRIPTION	Depth	MOIST	Sample No.	Sample Recovery	Lab Anal (Y/N)	N Valves (Blows)	F.I.D. or P.I.D./LEL	REMARKS
GP	Gravel, chert and sand poorly graded yellow, brown	21			6"				(20-22')
CL	Light reddish brown very fine grained weathered shale with clay	22							6-14-11-17
		23			2'				>0.5p (22-24')
		24							3-7-12-20
									(24-26')
	TS @ 24' bgs. Augu depth 22/bgs.								

## FIELD BORING LOG

Page 1 of 2

Project No.:		County: <u>St. Louis</u>		Boring No.: <u>SL 1982-3</u>		Monitor Well No.:	
Project Name: <u>St. Louis Army Ammunition Plant</u>		Surface Elev.:		Completion Depth: <u>233'</u>			
Fed ID No.:		Auger Depth: <u>21.2</u>		Rotary Depth: <u>N/A</u>			
State Planar Coordinates: N E		Date: <u>7/12/99</u>		Start Time: <u>10:00</u>		Finish Time: <u>12:30</u>	
Borehole Status: <u>Monitoring Well</u>		Groundwater Depth:		Method: <u>Hollow Stem Auger</u>			
Drilling Equipment:		Surface (circle one): Bare <u>(Grassy)</u> Wooded		PERSONNEL			
<u>CME-75</u> <u>4" Hollow Stem Auger</u> <u>2' Split Spoon Continuous</u> <u>Sampler</u>		SAMPLES				G. Robert Hall II D. Dale Meyers H. Chris Beck	
		MOIST		Sample No.		REMARKS	
USCS DESCRIPTION		Sample Recovery		Lab Anal (Y/N)		N Valves (Blows)	
Depth		F.I.D. or P.I.D./LEL Readings					
0		Dry		3" Concrete 5" Gravel			
1		Slightly		2-3-3-4 2.0P (13-5')			
2		Damp		3-3-4-6 3.25P (15-7')			
3				3-2-2-3 0.75P (7-9')			
4				2-2-4-5 2.5P (9-11')			
5				2-4-6-8 2.75P (11'-13')			
6				3-5-9-11 4.5P (13-15')			
7				3-6-8-10 4.0P (15-17')			
8				3-4-2-9 3.75P (17-19')			
9				2-4-6-8 3.0P (19-21')			
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							

# FIELD BORING LOG

Page 2 of 2

Project No.: Soil Boring No.: <u>SWMW-3</u> Logged by: <u>Robert Hill II</u>											G. <u>Robert Hill II</u> D. <u>Dale Meyer</u> I. <u>Chris Bells</u>	
USCS	DESCRIPTION	Depth	MOIST	Sample No.	Sample Recovery	Lab Anal (Y/N)	N Valves (Blows)	F.I.D. or P.I.D./LEL	REMARKS			
<u>ML</u> <u>CL</u>	<u>yellowish brown</u> <u>very fine grain</u> <u>clayey silt.</u>	<u>21</u>	<u>DA</u>						<u>(21-23')</u> <u>2-5-7-9</u> <u>3.75p</u>			
		<u>22</u>										
		<u>23</u>										
		<u>24</u>										
		<u>25</u>										
		<u>26</u>										
<u>TO @ 21.2' bgs</u> <u>Split Spoon depth</u> <u>23'</u>												

## FIELD BORING LOG

Page 1 of 2

Project No:		County: <u>St. Louis</u>		Boring No.: <u>Summary</u>		Monitor Well No.:	
Project Name: <u>St. Louis Army Ammunition Plant</u>				Surface Elev.: <u></u>		Completion Depth: <u>275</u>	
Fed ID No:				Auger Depth: <u>26</u>		Rotary Depth: <u>114</u>	
State Planar Coordinates: N. E.		Date: <u>7/12/99</u>		Start Time: <u>1:30</u>		Finish Time: <u>4:00</u>	
Borehole Status: <u>Monitoring Well</u>		Groundwater Depth:		Method: <u>Hand Driven Auger</u>			
Drilling Equipment: <u>CME 75</u>		Surface (circle one): <u>Bare</u>		Borehole Status: <u>Monitoring Well</u>			
		Grassy		Wooded			
		SAMPLES		PERSONNEL			
		MOIST		Sample No.		Sample Recovery	
				Lab Anal (Y/N)		N Valves (Blows)	
				F.I.D. or P.I.O./LEL Readings		REMARKS	
USCS	DESCRIPTION	Depth					
OL	brown fine grain clayey silt with roots (soft firm)	0					3-2-2-8 0.5P
CL	brown fine grain clayey silt with roots (soft firm)	1					1-2-5-7 0.75P
CL	brown fine grain clayey silt with roots (soft firm)	2					(4-6) 1-3-5-3 0.50P
CL	brown fine grain clayey silt with roots (soft firm)	3					(6-8) 1-3-5-3 0.50P
CL	brown fine grain clayey silt with roots (soft firm)	4					(8-10) 1-3-3-5 1.25P
CL	brown fine grain clayey silt with roots (soft firm)	5					(10-12) 2-3-4-6 2.0P
CL	brown fine grain clayey silt with roots (soft firm)	6					(12-14) 2-3-5-6 2.25P
CL	brown fine grain clayey silt with roots (soft firm)	7					(14-16) 3-6-8-11 4.0P
CL	brown fine grain clayey silt with roots (soft firm)	8					(16-18) 3-8-7-9 2.5P
CL	brown fine grain clayey silt with roots (soft firm)	9					(18-20) 4-6-8-8 2.25P
CL	brown fine grain clayey silt with roots (soft firm)	10					
CL	brown fine grain clayey silt with roots (soft firm)	11					
CL	brown fine grain clayey silt with roots (soft firm)	12					
CL	brown fine grain clayey silt with roots (soft firm)	13					
CL	brown fine grain clayey silt with roots (soft firm)	14					
CL	brown fine grain clayey silt with roots (soft firm)	15					
CL	brown fine grain clayey silt with roots (soft firm)	16					
CL	brown fine grain clayey silt with roots (soft firm)	17					
CL	brown fine grain clayey silt with roots (soft firm)	18					
CL	brown fine grain clayey silt with roots (soft firm)	19					
CL	brown fine grain clayey silt with roots (soft firm)	20					

# FIELD BORING LOG

Page 2 of 2

Project No.: <u>SAMW4</u> Soil Boring No.: <u>Robert Hill</u> Logged by: <u>Robert Hill</u>											G. <u>Robert Hill</u> O. <u>Dale Meyer</u> T. <u>Chris Brooks</u>	
USCS	DESCRIPTION	Depth	MOIST	Sample No.	Sample Recovery	Lab Anal (Y/N)	N Valves (Blows)	F.I.D. or P.I.D./LEL	Partly Sunny - 920 slight breeze REMARKS			
ML CL	Light yellowish brown clayey silt, no odor, very firm med. plasticity.	21	slightly damp	2'	2'				(20'-22')			
		22							3-4-6-8			
		23							2.75p			
		24							(22-24')			
CL	Light grayish brown clayey silt	25		2'					3-5-8-10			
		26		2'					3.5p			
		27		N/A					(24-26')			
		28		N/A					4-7-10-12			
GL	Black striations yellowish brown clayey silt	27							4.25p			
	Check modulus gravel	28							(26-28')			
	TD @ 27.5' bgs.											

# FIELD BORING LOG

Page 1 of 2

Project No.:		County: <u>St. Louis</u>		Boring No.: <u>SUNNY 5</u>		Monitor Well No.:			
Project Name: <u>St. Louis Ammunitions Plant</u>				Surface Elev.:		Completion Depth: <u>37.5</u>			
Fed ID No.:				Auger Depth: <u>36</u>		Rotary Depth:			
State Planar Coordinates: N. E.		Date: <u>7/8/97</u>		Start Time: <u>10:42</u>		Finish Time: <u>2:20</u>			
Borehole Status: <u>Monitoring Well</u>				Groundwater Depth:		Method: <u>Hollow stem Auger</u>			
Drilling Equipment: <u>CME-75</u> <u>4" Hollow stem Auger</u> <u>2' Split Spoon Continuous Sampler</u>				Surface (circle one): <u>Bare</u> Grassy Wooded		PERSONNEL G- <u>Robert Hill II</u> D- <u>Dale Meyer</u> H- <u>Chris Bucks</u>			
				SAMPLES					
USCS	DESCRIPTION	Depth	MOIST	Sample No.	Sample Recovery	Lab Anal (Y/N)	N Valves (Blows)	F.I.D. or P.I.D./LEL Readings	REMARKS
	<u>Bituminous Asphalt</u>	<u>0</u>							<u>(0-2')</u>
	<u>Concrete</u>	<u>1</u>	<u>Dry</u>						<u>5-7-3-4</u> <u>1.0p</u>
<u>GP</u>	<u>Gravel w/sand</u>	<u>2</u>							<u>(2-4')</u>
	<u>light yellowish brown</u>	<u>3</u>			<u>20"</u>				<u>6-9-5-5</u>
	<u>very fine grained</u>	<u>4</u>	<u>Dry</u>						<u>1.15p</u>
	<u>clayey silt - low</u>	<u>5</u>			<u>2'</u>				<u>(4-6')</u>
<u>ML</u>	<u>(No odor) Firm</u>	<u>6</u>							<u>2-2-3-3</u> <u>0.80p</u>
<u>CL</u>		<u>7</u>							<u>(6-8')</u>
		<u>8</u>	<u>DAMP</u>		<u>2'</u>				<u>2-2-2-3</u> <u>1.0p</u>
	<u>Visible water noted</u>	<u>9</u>	<u>MOIST</u>						<u>(8-10')</u>
	<u>in soil sample core</u>	<u>10</u>	<u>DAMP</u>		<u>2'</u>				<u>0.1-2-2-3</u> <u>0.75p</u>
	<u>center</u>	<u>11</u>			<u>2'</u>				<u>(10-12')</u>
		<u>12</u>	<u>Dry</u>						<u>1-2-3-5</u> <u>2.5p</u>
	<u>soil very slightly</u>	<u>13</u>	<u>DAMP</u>		<u>2'</u>				<u>(12-14')</u>
	<u>damp</u>	<u>14</u>							<u>1-3-4-5</u> <u>2.75p</u>
<u>ML</u>		<u>15</u>			<u>2'</u>				<u>(14-16')</u>
<u>CL</u>		<u>16</u>							<u>10-4-5-6</u> <u>1.0p</u>
	<u>soil less damp</u>	<u>17</u>	<u>Dry</u>		<u>2'</u>				<u>(16-18')</u>
	<u>FIRM</u>	<u>18</u>							<u>2-3-5-6</u> <u>2.2p</u>
		<u>19</u>			<u>2'</u>				<u>(18-20')</u>
<u>ML/CL</u>	<u>grayish brown very</u>	<u>20</u>							<u>3-5-6-8</u> <u>3.6p</u>
	<u>fine grained</u>								
	<u>clayey silt</u>								

FIELD BORING LOG

Page 2 of 2

Project No.: SWUJ-5 Soil Boring No.: Robert H. Hill # Logged by:				G- Robert H. Hill # D- Dale Meyers H- Chris Buckles					
USCS	DESCRIPTION	Depth	MOIST	Sample No.	Sample Recovery	Lab Anal (Y/N)	N Valves (Blows)	F.I.D. or P.I.D./LEL	REMARKS
ML	Light yellowish brown very fine grained, non plastic, (no odor)	21	dry	21					(20-22')
ML	Light grayish brown clayey silt, very fine grained, low plasticity	22	dry	22					3-6-8-12 4.25p (22-24')
ML	Gravel, sand with chest nodules, brown, crumbly	23	dry	23					2-5-7-9 3.5p (24-26')
CL	Light reddish brown weathered shale, clayey, olive weathered	24	dry	24					2-5-7-10 2.9p (26-28')
CL	Shale, clay, yellow, very fine grain weathered shale	25	dry	25					2-15-23-25 3.6p (28-30')
CL	Light gray very fine grained silt, weathered shale very firm to hard non plastic, high dry strength (sandy surface)	26	dry	26					3-7-12-18 3.1p (30-32')
CL	But gray silty shale	27	dry	27					2-5-20-20 2.45p (32-34')
CL	TD @ 37 3/4" bgs + 0.5'	28	dry	28					10-24-32-72 2.45p (34-36')
CL	Spoon refusal @ 50 blows + 160 3/4"	29	dry	29					13-28-54-125 2.40p (36-38')
CL		30							4-30-48-50 3/4"
CL		31							
CL		32							
CL		33							
CL		34							
CL		35							
CL		36							
CL		37							
CL		38							

# FIELD BORING LOG

Page 1 of 1

Project No.:		County: <u>St. Louis</u>		Boring No.: <u>800000</u>		Monitor Well No.:	
Project Name: <u>St. Louis Army Ammunition Plant</u>				Surface Elev.:		Completion Depth: <u>21'</u>	
Fed ID No.:				Auger Depth: <u>19</u>		Rotary Depth: <u>N/A</u>	
State Planar Coordinates: N. E.				Date: <u>7/12/99</u>		Start Time: <u>4:41</u> Finish Time: <u>5:30</u>	
Borehole Status: <u>Monitoring Well</u>				Groundwater Depth:		Method: <u>Hollow stem Auger</u>	
Drilling Equipment: <u>CME-75</u> <u>4" Hollow stem Auger</u> <u>2" Split Spoon Continuous Sampler</u>				Surface (circle one): <u>Bare</u> Grassy Wooded			
				SAMPLES			
				PERSONNEL			
				G. <u>Robert Hill</u> D. <u>Dale Moyers</u> H. <u>Chris Black</u>			
				REMARKS			
				<u>Sunny 92° breeze</u>			
USCS	DESCRIPTION	Depth	MOIST	Sample No.	Sample Recovery	Lab Anal (Y/N)	N Valves (Blows)
							F.I.D. or P.I.D./L/L Readings
Gr	<del>Extensive Asphalt</del>	0					
		1					
ML	Light yellowish brown very fine grained clayey silt	2	damp		2'		
CL		3					
		4			2'		
	yellowish brown very fine grain clayey silt med. to high plasticity (no odor)	5	very damp				
ML		6			2'		
CL		7	moist				
		8			2'		
		9					
ML	Light yellowish brown very fine grain clayey silt med. plasticity (no odor)	10	damp		2'		
CL		11					
		12			2'		
		13	slightly damp				
		14			2'		
		15					
		16			2'		
Gr	Chert and gravel coarse grained poorly graded	17					
		18			2'		
CL	Light reddish brown very fine grain weathered shale with clay	19					
		20			2'		

TD @ 19 bgs Auger  
Split Spoon @ 21' bgs



# FIELD BORING LOG

Page 1 of 2

Project NO.:		County: <u>St. Louis</u>		Boring No.: <u>SW-6-7</u>		Monitor Well No.:			
Project Name: <u>St. Louis Ammunition Plant</u>				Surface Elev.:		Completion Depth: <u>34</u>			
Fed ID No.:				Auger Depth: <u>32</u>		Rotary Depth: <u>N/A</u>			
State Planar Coordinates: N. E.			Date: <u>7/7/99</u>		Start Time: <u>1:15</u>		Finish Time: <u>4:11</u>		
Borehole Status: <u>Monitoring Well</u>				Groundwater Depth: <u>12</u>		Method: <u>Hollow stem Auger</u>			
Drilling Equipment: <u>CAGE 75</u> <u>1" Hollow stem Auger</u> <u>2" Split spoon continuous sampling</u>				Surface (circle one): <u>Bare</u> Grassy Wooded					
				SAMPLES			PERSONNEL		
							G. Robert Hill II D. Dale Meyer T. Chris Ecks		
USCS	DESCRIPTION	Depth	MOIST	Sample No.	Sample Recovery	Lab Anal (Y/N)	N Values (Blows)	F.I.D. or P.I.D./LEL Readings	REMARKS
	<u>Bituminous Asphalt</u>	<u>0</u>			<u>0</u>			<u>N/A</u>	<u>3" Asphalt/3" gravel</u>
	<u>Light yellowish brown</u>	<u>1</u>							<u>(0.5-2.5)</u>
	<u>Clayey silt very fine</u>	<u>2</u>	<u>DRY</u>		<u>2'</u>				<u>1.75p (1-3-2-2)</u>
	<u>grained, medium</u>	<u>3</u>							<u>(2.5-4.5)</u>
	<u>plasticity, medium</u>	<u>4</u>			<u>2'</u>				<u>(1-2-1-2)</u>
	<u>dry strength</u>	<u>5</u>							<u>2.5p</u>
		<u>6</u>			<u>2'</u>				<u>(4.5-6.5)</u>
		<u>7</u>	<u>DRY</u>						<u>(1-1-1-2)</u>
	<u>grayish brown clayey silt</u>	<u>8</u>	<u>DRY</u>		<u>2'</u>				<u>(6.5-8.5)</u>
	<u>Light yellowish</u>	<u>9</u>	<u>DRY</u>						<u>(1-1-2-2)</u>
	<u>brown very fine</u>	<u>10</u>			<u>15"</u>				<u>(8.5-10.5)</u>
	<u>grained clayey silt</u>	<u>11</u>							<u>2-2-3-2</u>
	<u>medium plasticity</u>	<u>12</u>			<u>22"</u>				<u>0.75p</u>
	<u>(crumbly &amp; dry)</u>	<u>13</u>							<u>(10.5-12.5)</u>
		<u>14</u>			<u>2'</u>				<u>(1-2-4-5)</u>
		<u>15</u>							<u>(12.5-14.5)</u>
	<u>very coarse grain</u>	<u>16</u>			<u>23"</u>				<u>(1-2-3-4)</u>
	<u>and gravel &amp; chert</u>	<u>17</u>							<u>1.0p</u>
	<u>Light reddish brown</u>	<u>18</u>	<u>DRY</u>		<u>2'</u>				<u>(14.5-16.5)</u>
	<u>very fine grained non-</u>	<u>19</u>							<u>(1-8-17-17)</u>
	<u>plastic, high dry</u>	<u>20</u>			<u>2'</u>				<u>2.0p</u>
	<u>strength weathered</u>								<u>(6.5-18.5)</u>
	<u>shale or clay,</u>								<u>(2-5-9-14)</u>
									<u>2.5p</u>
									<u>(18.5-20.5)</u>
									<u>(4-8-11-17)</u>
									<u>3.0p</u>

FIELD BORING LOG

Page 2 of 2

Project No.: SO-0007-7 Soil Boring No.: Robert Hill II Logged by:		G- Robert Hill II D- Dale Meyer H- Chris Ellis							
USCS	DESCRIPTION	Depth	MOIST	Sample No.	Sample Recovery	Lab Anal (Y/N)	N Valves (Blows)	F.I.D. or P.I.D./LEL	REMARKS
CL	light reddish brown very fine grained weathered shale or clayey shale	21	dry	21				N/A	(20.5-22.5) 5-13-23-28
CL	Pale olive very fine grained weathered shale or clayey shale	22	dry						(22.5-24.5) 8-14-15-15 3.0P
CL	Yellow very fine grain silty weathered shale or clayey shale	23	dry	21					(24.5-26.5) 6-9-12-15 74.5P
CL	light gray very fine grained silty weathered shale with clay. High dry strength	24	dry	21					(26.5-28.5) 4-22-22-37
CL		25	dry	21					(28.5-30.5) 15-27-53-107 74.5P
CL		26	dry	21					(30.5-32.5) 13-24-52-119
CL		27	dry	21					(32.5-34.5) 14-48-170-129/1.5 74.5P
CL		28	dry	21					
CL		29	dry	21					
CL		30	dry	21					
CL		31	dry	21					
CL		32	dry	21					
CL		33	dry	21					
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FIELD BORING LOG

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Project No.:		County:		Boring No.: 2nd-1		Monitor Well No.:			
Project Name: St Louis Army Ammunition Plant				Surface Elev.:		Completion Depth: 20'			
Fed ID No.:				Auger Depth: 18'		Rotary Depth:			
State Planar Coordinates: N. E.				Date: 7/13/99		Start Time: 3:15			
Borehole Status: Monitoring Well				Groundwater Depth:		Method: Helicoid Stem Auger			
Drilling Equipment: CME-75 4" Helicoid Stem Auger 2' Split Spoon Continuous Sampler				Surface (circle one): <input checked="" type="radio"/> Bare <input type="radio"/> Grassy <input type="radio"/> Wooded		Finish Time: 4:00			
USCS	DESCRIPTION	Depth	MOIST	Sample No.	Sample Recovery	Lab Anal (Y/N)	N Valves (Blows)	F.I.D. or P.I.D. / LEL Readings	PERSONNEL
									REMARKS
GM	Gravel with sand, light gray and coarse well-graded	0							Robert Hill D. Dale Meyer H. Chris Bricks
		1	OK	1'					
		2							
		3							
		4	OK						
		5		2'					
		6							
		7		2'					
		8	WET						
		9	WET	2'					
ml/c	fine yellowish brown very fine grain clayey silt (no odor) <u>WET</u>	10							No page number heading (4-6)
		11		2'					
		12							
		13		2'					
ml/c	reddish brown weathered shale with clay/non-plastic	14							6-10-10-5 No page number heading (4-6)
		15							
		16		2'					
		17							
ml/c	fine olive very fine grain weathered shale with clay	18							10-18-35-32 No page number heading (4-6)
		19							
		20		2'					
		21							

## FIELD BORING LOG

Page 1 of 1

Project No.:		County: <u>St. Louis</u>		Boring No.: <u>10MW-1</u>		Monitor Well No.:		
Project Name: <u>St. Louis Army Ammunition Plant</u>				Surface Elev.:		Completion Depth: <u>20</u>		
Fed ID No.:				Auger Depth: <u>20</u>		Rotary Depth: <u>N/A</u>		
State Planar Coordinates: N. E.				Date: <u>7/13/99</u>		Start Time: <u>10:40</u> Finish Time: <u>12:53</u>		
Borehole Status: <u>Monitoring Well</u>				Groundwater Depth:		Method:		
Drilling Equipment: <u>CME 75</u> <u>4" Hollow stem Auger</u> <u>2' Split Spoon continuous sampler</u>				Surface (circle one): <u>bare</u> Grassy Wooded				
				SAMPLES				
				PERSONNEL				
				G. <u>Robert Hill II</u> H. <u>Dale Meyer</u> I. <u>Chris Bucks</u>				
				REMARKS				
				<u>Partly Sunny</u> <u>87° - Breezy</u>				
USCS	DESCRIPTION	Depth	MOIST	Sample No.	Sample Recovery	Lab Anal (Y/N)	N Valves (Blows)	F.I.D. or P.I.D./LEL Readings
		0						
		1			17"			19.5 ppm
	yellowish brown very fine grain clayey silt (no odor)	2						4.5p
		3			18"			21.5 ppm
		4						1-2-3-4 74.5p
	light yellowish brown very fine grained clayey silt (no odor)	5			2'			18.2 ppm
		6						2-3-4-5 3.25p
		7			2'			22.4 ppm
		8						1-2-3-3 2.5p
		9			2'			22.9 ppm
		10						2-3-3-3 2.20p
		11			2'			13.8 ppm
		12						1-2-2-3 2.5p
		13			2'			18.5 ppm
		14						1-3-3-5 1.25p
		15			2'			18.3 ppm
		16						2-2-3-5 3.5p
		17			2'			17.5 ppm
		18						1-3-4-7 3.25p
		19			2'			16.9 ppm
		20						2-3-3-5 3.0p
	check							

APPENDIX L

EQUIPMENT CALIBRATION

## Align Local Coordinates (A)

---

SurvStar reads a LAT/LONG position from the GPS receiver which is converted to a state plane coordinate. Using local coordinate points and their corresponding GPS position, Align Local Coordinates applies a transformation to convert the state plane coordinate to the local. SurvStar can operate in three different modes depending on the Align Local Coordinate settings:

- No alignment
- One point alignment
- Two or more point alignment

Without Align Local Coordinates set, SurvStar will operate with no alignment which directly uses the state plane coordinates. In order for the coordinates to be the true state plane coordinates in this alignment mode, the GPS base receiver must be set up over a known point and the true Lat/Long for the point must be entered in the base as the base position. Otherwise, if the base is set over an arbitrary point, then the coordinates will not be true state plane.

In one point alignment mode, one pair of GPS and local coordinates is specified in Align Local Coordinates. The differences between the GPS and local northing, easting and elevation for these points are used as the translation distances in the transformation. The rotation will use either the state plane grid or the geodetic as north. The rotation type is specified in the Alignment Options menu. No scale is applied in this transformation.

One point alignment is useful for data collection on a new site. In this case you can set the GPS base receiver up anywhere convenient. Then position the rover over the first point and run Align Local Coordinates. Add this one alignment point by reading the GPS point and entering a local coordinate like 5000,5000,100. Now the local coordinate system is set around this first point at 5000,5000,100.

A two or more point alignment is used to align to an existing local coordinate system. At least two pairs of local and GPS coordinates must be entered. Two pairs of points is sufficient to define the translation, rotation and scale for the transformation. If more than two points are entered, the program will find a least squares best fit transformation and will report the "residuals".

For entering the local coordinate, you can either enter the northing, easting and elevation or specify a point number. To enter the GPS position that matches this local coordinate, you can either set up the rover over the local point and read the GPS receiver or enter the GPS LAT/LONG for that point. In order to use the LAT/LONG, you must set up the base over a known point and enter the correct LAT/LONG at the base. Reading the position from the GPS receiver does not have this restriction which allows you to set up the base at any point.

Use the hot key "A" to enter the Align Local Coordinates feature. You will first be presented with the values you have selected for pertinent alignment settings. At the prompt, simply press enter if all settings are as they should be, or type 'N' and enter to jump to the Job Options menu where you can modify any incorrect settings. Once you exit the Job Options menu, you will continue with the Align Local Coordinates process.

The next screen displays a list of the points used for the alignment. To Add a new alignment point, type A or F1. To remove a point, highlight the point using the up and down arrow keys and then press D or F3. If you have entered a local coordinate or description value that is incorrect, you may type E or F3 to edit these values (*\*New Feature*). This will not modify any points you have already stored, but you can use the Process GPS Raw File option (hotkey 'RAW') under the Point Utilities menu to reprocess the previously stored points with the new alignment.

Press M or F4 to toggle the bottom menu for more options. Use Load (L) to recall a previously stored alignment file. Be very careful to ensure that your current base configuration is exactly as it was when the alignment was stored. Because the alignment links local coordinates to GPS coordinates, if the latitude and longitude value at your base changes for any reason whatsoever, you must also change your alignment file. The View option switches between showing the local coordinates and the corresponding GPS LAT/LONG coordinates. The On/Off option allows you to switch whether the highlighted point is used for the horizontal and/or vertical alignment. The H column represents horizontal control and the V column vertical control. For example, you may wish to use 2 points for horizontal alignment and one for vertical (YN).

In the local points view, the HRes column shows the horizontal residual and the VRes column shows the vertical residual. The residual is the difference between the actual point and the point calculated using the alignment transformation. In GPS points view, the HRMS and VRMS columns show the horizontal and vertical RMS values when that point was recorded.

Northing	Eastng	Elev	HRes	VRes	HV
Description					

5000.00	5000.00	993.50	0.0	0.0	YY
---------	---------	--------	-----	-----	----

MH #4

5324.52	4739.43	970.23	0.0	0.0	YY
---------	---------	--------	-----	-----	----

MH #5

ESC:Exit F1:Add F2:Del F3>Edit F4:Menu

Local coordinates view.

Lat	Long	Elev	HRes	VRes	HV
Description					

GPS coordinates view.

41.153943 83.031243 992.87 0.03 0.04 YY  
MH #4  
41.150232 83.034811 970.42 0.03 0.03 YY  
MH #5  
ESC:Exit F1:Load F2:View F3:On F4:Menu

To start a new local coordinate system, enter one pair of local and GPS coordinates. SurvStar will then do a translation but not a rotation or scale. North for the GPS coordinates will be the same north for the local coordinates.

In addition to the northing and easting transformation, SurvStar will also translate the elevation from the GPS system to the local. The elevation difference between the two systems is modeled by a best-fit plane.

When SurvStar starts, there is no alignment data and the system is in state plane coordinates. To recall a previously entered alignment, use the Load option in the Align Local Coordinates menu. You will be prompted to enter the filename of the alignment you wish to load. Alignment files are stored in the DATA directory with ".dar" extensions.

Load alignment is only valid if the base receiver setup has not changed since the alignment points were recorded. If you had to exit SurvStar or turn off the Husky while in the field, then when you restart SurvStar you can run Load Alignment. In order to use an alignment when returning to a site, you must set up the base receiver in the same position and enter the same LAT/LONG coordinates for the base.

When you exit the Align Local Coordinates menu, the program will ask you if you want to save the changes. Say yes to apply these alignment points to your GPS session and save them to a file for future reference. If you loaded points from a file, they will be saved to the same file. Otherwise, enter a filename at the prompt.

## Typical Alignment Scenarios

---

**Scenario:** New site. In this case, there are no established coordinates on the site.

**Alignment:** Choose a point on site and do a one point alignment. For the local alignment point, enter the coordinates that you would like to use (ie 5000,5000,100). The One Pt Align Azimuth option chooses between using true north (geodetic) or state plane north (grid). To use real world ground distances, set the Project Scale Factor. Otherwise the default scale factor of 1.0 will collect points on state plane distances.

**Scenario:** One known state plane coordinate and you want to work in the state plane



coordinate system.

**Alignment:** Do a one point alignment on this known state plane point. Set the One Point Align Azimuth to Grid and set the scale factor to 1.0.

**Scenario:** Multiple known control points.

**Alignment:** Choose two or more control points to align to. It is best to use control points around the perimeter of the site. Use as many control points as are available or enough to envelope the site. Set the Transformation to Plane Similarity to fit the GPS points onto the control points. Set the Project Scale Factor to 1.0. After making the alignment, stake out another control point (ideally one that is not used in the alignment) to make sure the alignment is good.

## Setup (SU)

---

This screen controls several of the GPS receiver settings. A more detailed explanation of these settings can be found in the GPS receiver documentation. The options that are available in this menu depend on the type of GPS receiver.

## NovAtel

---

### GPS Control

1. Equip Type - NovAtel
2. Satellite Position
3. Elevation Cutoff - 10.0
4. Configure Base Station
4. Select Base Station ID
5. Station Type - ROVER
6. Mode - RTCA
7. Base Rate - 1
8. Send Command to Receiver
9. Receiver Reset (Full Initialize)
10. Solution Reset (Soft Reboot)
11. Dynamics - Kinematic
12. Set Radio Channel
13. Check Comm. Status
14. PC Card Utilities

\*If Base is the Station Type

\*If Rover is the Station Type

\*for DL Logpak receiver only

## 4.7 Calibration of MiniRAE Plus

In the Hygiene Mode, the user may re-calibrate the MiniRAE Plus Professional PID Unit. This is a two-point calibration process using "zero gas" and standard reference gas. First, a "zero gas" which contains no detectable organic vapors is used to set the zero point (C0). Then a standard reference gas which contains a known concentration of a specific gas is used to set the second point of reference (C1). The calibration procedures are detailed below.

**Note:** if the security level of the unit is set to "no change allowed"(level 0), both zero gas and standard gas calibration menu will not be displayed.

### 4.7.1 Zero Gas Calibration

The organic vapor zeroing kit, see Figure 4.1, is supplied to perform zero gas calibration. This kit consists of

- Calibration adapter to link up with the gas inlet tube of the Professional PID Unit
- Charcoal filter to exclude any organic gas

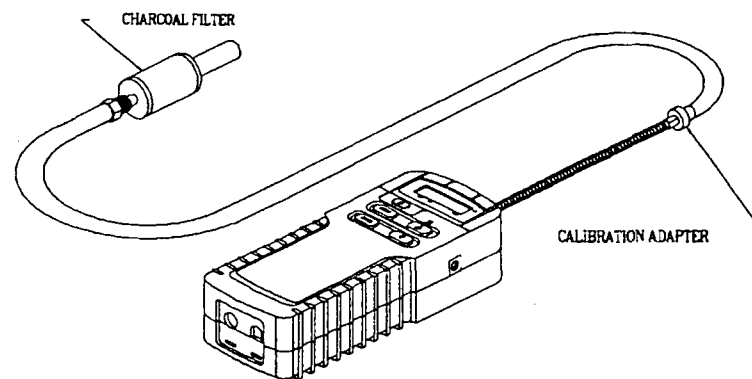


Figure 4.1 Zero gas calibration setup

### Zero Gas Calibration Procedure

1. "Zero gas calibration" option is the 5th menu option in Table 4.1.
  - Display shows "C0 xxx.x" where "xxx.x" is the gas reading based on current calibration of the instrument. Note: this reading may not be zero due to back ground gas concentration, dirty charcoal filter or instrument drift .
2. Insert the zero gas adapter into the gas inlet tube of the Personal PID Unit, as shown in Fig. 4.1.
3. The sampling pump draws air sample into the sensor chamber through the charcoal filter of the organic zeroing kit. The air entering the sensor chamber should be free of any organic vapors.
  - Display then shows the reading of the gas free of organic vapor. Again, this reading may not be zero due to dirty charcoal filter or instrument drift .

4. If this reading is not zero, press [enter] key to zero it. If the reading still shows a small value after a few seconds, press [enter] key again to zero it. Repeat this process until the reading is stabilized around zero or 0.1 ppm. This completes the zero gas calibration procedure. Press [menu] key to exit zero gas calibration and move on to next menu item.
5. Remove the zero gas calibration adapter from the Personal PID unit.
6. One may press [menu] key before pressing [enter] key in step 4 to skip the zero gas calibration. In this case, the previously stored zero gas calibration data is not changed.

**Note:** even if the reading shows a zero during step 4, it is recommended to press [enter] key at least once to ensure that the zero gas calibration is updated properly.

### 4.7.2 Enter Standard Calibration Gas Value

1. "Enter standard gas value" option is the 6th menu option in Table 4.1.
  - Display shows "Clu xxx.x" where "xxx.x" is the previously stored standard calibration gas value. For example, "Clu 100.0" will be shown when the unit is first shipped from the factory because it is calibrated using 100 ppm isobutylene gas as standard calibration gas.
2. If the concentration of the standard calibration gas to be used is the same as the displayed value, press **[enter]** key 4 times to accept the displayed calibration value one digit at a time and move to step 4.
3. If the concentration of the standard calibration gas to be used is different from the displayed value, user needs to enter the new value. Starting from the left-most digit of the displayed value, use **[up]** or **[down]** arrow key to change the digit value and **[enter]** key to confirm the digit, the flashing digit will move to next digit to its right. Repeat this process until all 4 digits are entered.

4. Now the standard calibration gas value is entered.
  - Display shows a flashing message of "GAS On" to remind user to turn on the standard calibration gas bottle now. After the gas bottle is turned on, press **[enter]** key to continue the standard gas calibration procedure as described in section 4.7.3.
5. Any time during step 2 or step 3, if the **[menu]** key is pressed, the data entry operation will be aborted. It is also assumed that user want to skip the standard gas calibration procedure and move on to the next menu item. Therefore, it is very important that all 4 digits are entered ( i.e. press **[enter]** key 4 times ) even if user does not want to change the standard calibration gas value in step 2.

### 4.7.3 Standard Reference Gas Calibration

Figure 4.2 shows the typical installation of standard reference gas calibration. It includes:

- Calibration adapter with flow controller
- Reference gas bottle of 100 ppm isobutylene

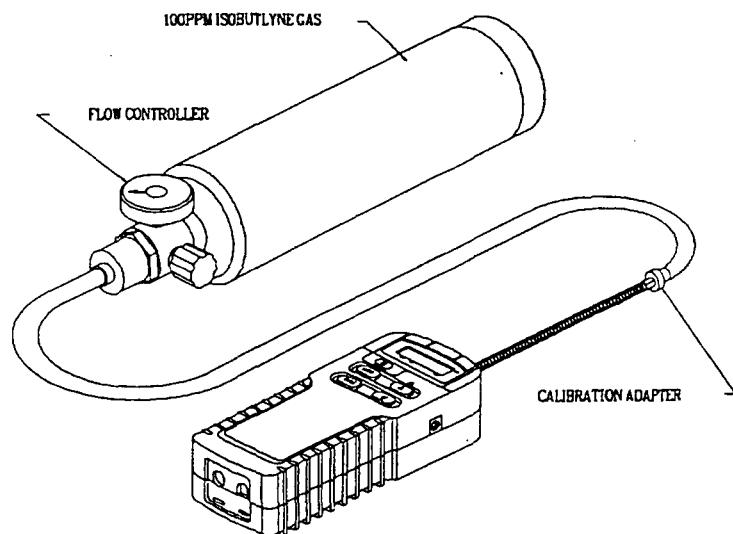


Figure 4.2 Standard reference gas calibration setup

### Standard Gas Calibration Procedure

1. Insert the calibration adapter into the gas inlet tube of the Personal PID Unit, and connect the calibration adapter with the standard gas bottle, as shown in Figure 4.2.
2. Continue from the step 4 of the previous section, the display should show a flashing message of "GAS On". Turn the flow controller knob counter-clockwise about half a turn to start the flow of gas then press **[enter]** key.
  - Display shows "CAL ..." for about 30 seconds while the instrument performs calibration. Afterward, the display shows "C1 xxx.x" where C1 indicates that this is the standard calibration gas and "xxx.x" is the actual gas reading in ppm based on new calibration data.

**Note:** the reading should be very close to the value of the given calibration gas ( e.g. 100.0 ppm ). If the reading is higher or lower than the standard gas value and continues to rise slowly, it means that the calibration gas has not been stabilized yet. Wait a few more seconds until the reading is stabilized then press **[enter]** key again. Every time the **[enter]** key is pressed, the instrument measures the current gas

concentration and calibrate accordingly. The new reading should be closer to the standard gas value. Repeat this process a few more times if necessary until the reading is stable and sufficiently close (within 1 or 2 ppm) to the standard gas value. This completes the standard gas calibration procedure.

3. Press **[menu]** key to exit the standard gas calibration procedure and move to next menu item.
4. Turn the flow controller knob fully clockwise to turn off the flow of gas. Disconnect the calibration adapter from the Personal PID Unit.
5. One may press **[menu]** key any time before pressing **[enter]** key in step 2 to abort the calibration. In this case, the previously stored calibration data is not changed.

**Note 1:** If **[enter]** key is pressed inadvertently during step 2 before the standard reference gas starts to flow, an error message of "CAL Err" will be displayed. Simply turn on the gas flow, wait for it to stabilize and press the **[enter]** key. This should allow the instrument to be calibrated. In case user does not have a calibration gas, then press **[menu]** key to exit step 2. A factory preset value will be used to calculate the standard gas calibration.

**Note 2:** The other possible cause for the "CAL Err" message to be displayed is that the instrument does not have enough sensitivity for the given calibration gas. There are several reasons for low sensitivity. First, the instrument and lamp is not sensitive to the specific calibration gas. In this case, user needs to use a higher concentration of the given calibration gas as the calibration standard, use a different calibration gas or use a higher energy lamp. The second reason is that the UV light intensity of the lamp is weak. In this case, replace the UV lamp with a newer and stronger one.

## 2.6.1 CALIBRATION PROCEDURES

---

The following calibration procedures are for the most commonly used sensors. For detailed information on all calibration procedures, refer to **Section 2.9.2, Calibrate**.

To ensure more accurate results, you can rinse the calibration cup with water, and then rinse with a small amount of the calibration solution for the sensor that you are going to calibrate. Discard the rinse solution and add fresh calibrator solution. Use tables 1, 2 and 3 to find the correct amount of calibrator solution.

1. Carefully immerse the probes into the solution and rotate the calibration cup to engage several threads. YSI recommends supporting the sonde with a ring stand and clamp to prevent the sonde from falling over.
2. With a field cable connecting the sonde to a PC, access EcoWatch for Windows and proceed to the Main menu (for information on how to run EcoWatch for Windows software, see **Section 2.4.2, Running EcoWatch Software**). From the sonde Main menu, select number **2-Calibrate**.

- Note that the exact appearance of this menu will vary depending upon the sensors that are available and enabled on your sonde. To select any of the parameters from the Calibrate menu, input the number that is next to the parameter and press **Enter**. Once you have chosen a parameter, some of the parameters will have a number that appears in parentheses. These are the default values and will be used during calibration if you press **Enter** without inputting another value. If no default value appears, you must type a numerical value and press **Enter**.

```

-----Calibrate-----
1-Conductivity          5-ISE2 ORP
2-Dissolved Oxy         6-ISE3 NH4+
3-Pressure-Abs          7-ISE4 NO3-
4-ISE1 pH               8-Turbidity

Select option (0 for previous menu):

```

- After you input the calibration value, or accept the default, press **Enter**. A real-time display will appear on the screen. Carefully observe the stabilization of the readings of the parameter that is being calibrated. When the readings have been stable for approximately 30 seconds, press **Enter** to accept the calibration. The calibrated value is bolded on the example screen on the following page.
- Press **Enter** to return to the Calibrate menu, and proceed to the next calibration.

**NOTE:** If an ERROR message appears, begin the calibration procedure again. Be certain that the value you enter for the calibration standard is correct. Also see **Section 6, Troubleshooting** for more information on error messages. If you continue to observe error messages during calibration, contact YSI Customer Service. See **Section 8, Warranty and Service Information**.

```

=====
Temp SpCond  Sal DOsat  DO  Depth  pH NH4+ N NO3- N Turbid
   C  mS/cm   ppt      %  mg/L   feet          mg/L  mg/L  NTU
-----
To calibrate, press <Enter> when the readings are stable.
23.52  7.496  4.13  98.4  8.36  0.310  7.15  11.03  0.000  0.9

```

You will find specific start-up calibration procedures for all sensors that commonly require calibration in the following sections. If a sensor listed is not installed in your sonde, skip that section and proceed to the next sensor until the calibration protocol is complete. Before you use the sonde in the laboratory or field, read and study the more-detailed information on calibration in **Section 2.9.2, Calibrate**.

Temperature does not require calibration, and is therefore not included in the Calibrate menu. ORP calibration is required only infrequently and is only discussed in **Section 2.9.2, Calibrate**.



## CONDUCTIVITY

---

This procedure calibrates conductivity, specific conductance, salinity, and total dissolved solids.

Place approximately the correct amount (by using tables 1, 2 and 3) of conductivity standard into a clean, dry or pre-rinsed calibration cup.

For maximum accuracy, the conductivity standard you choose should be within the same conductivity range as the water you are preparing to sample. However, we do not recommend using standards less than 1 mS/cm. For example:

- ✓ For fresh water use a 1 mS/cm conductivity standard.
- ✓ For brackish water use a 10 mS/cm conductivity standard.
- ✓ For seawater use a 50 mS/cm conductivity standard.

Before proceeding insure that the sensor is as dry as possible. Ideally, rinse the conductivity sensor with a small amount of standard that can be discarded. Be certain that you avoid cross-contamination of standard solutions with other solutions. Make certain that there are no salt deposits around the oxygen and pH/ORP probes, particularly if you are employing standards of low conductivity.

Carefully immerse the probe end of the sonde into the solution. Gently rotate and/or move the sonde up and down to remove any bubbles from the conductivity cell. The probe must be completely immersed past its vent hole. Using the recommended volumes from the table in the previous subsection should insure that the vent hole is covered.

Allow at least one minute for temperature equilibration before proceeding.

From the Calibrate menu, select number **1-Conductivity** to access the Conductivity calibration procedure and then number **1-SpCond** to access the specific conductance calibration procedure. Enter the calibration value of the standard you are using (mS/cm at 25°C) and press **Enter**. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.

Observe the readings under Specific Conductance or Conductivity and when they show no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to return to the Calibrate menu.

Rinse the sonde in tap or purified water and dry the sonde.

## DISSOLVED OXYGEN

---

Place approximately 3 mm (1/8 inch) of water in the bottom of the calibration cup. Place the probe end of the sonde into the cup. Make certain that the DO and temperature probes are not immersed in the water. Engage only 1 or 2 threads of the calibration cup to insure the DO probe

is vented to the atmosphere. Wait approximately 10 minutes for the air in the calibration cup to become water saturated and for the temperature to equilibrate.

Two calibration protocols are provided below for dissolved oxygen, one for sampling applications and one for long-term monitoring applications.

### Sampling Applications

If your instrument will be used in sampling applications where the dissolved oxygen is pulsing continuously, deactivate "Autosleep RS232" as described in **Section 2.5, Sonde Software Setup**.

From the Calibrate menu, select number **2-Dissolved Oxy**, then number **1-DO %** to access the DO percent calibration procedure. Calibration of dissolved oxygen in the DO % procedure also results in calibration of the DO mg/L mode and vice versa.

Enter the current barometric pressure in mm of Hg. (Inches of Hg x 25.4 = mm Hg).

**Caution:** Barometer readings that appear in meteorological reports are generally corrected to sea level and are not useful for your calibration procedure unless they are uncorrected.

Press **Enter** and the current values of all enabled sensors will appear on the screen and change with time as they stabilize. Observe the readings under DO %. When they show no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to return to the Calibrate menu.

Rinse the sonde in water and dry the sonde.

### Monitoring Applications

If your instrument will be used in monitoring applications where data is being captured at a longer interval (e.g. 15 – 60 minutes) to internal sonde memory, a data collection platform or a computer, you need to activate "Autosleep RS232" as described in **Section 2.5, Sonde Software Setup**. Then follow the instructions detailed above for the Sampling Application calibration. With Autosleep active, the calibration will occur automatically with a display similar to that shown below.

Temp	SpCond	Sal	DOsat	DO	Depth	pH	NH4+	N	NO3-	N	Turbid
C	ms/cm	ppt	%	mg/L	feet		mg/L		mg/L		NTU
-----											
Stabilizing: 38											

After the warm-up time is complete, the readings just before and just after calibration are displayed. When you press **Enter**, the screen returns to the DO Calibration menu.

## DEPTH AND LEVEL

---

For the depth and level calibration, you can leave the sonde set up the same way as for dissolved oxygen, in water-saturated air.

From the Calibrate menu, select number **3-Pressure-Abs** (or number **3-Pressure-Gage** if you have a vented level sensor) to access the depth calibration procedure. Input 0.00 or some known sensor offset in feet. Press **Enter** and monitor the stabilization of the depth readings with time. When no significant change occurs for approximately 30 seconds, press **Enter** to confirm the calibration. This zeros the sensor with regard to current barometric pressure. Then press **Enter** again to return to the Calibrate menu.

For best performance of depth measurements, users should ensure that the sonde's orientation remains constant while taking readings. This is especially important for vented level measurements and for sondes with side mounted pressure sensors.

## pH 2-POINT

---

Using the correct amount of pH 7 buffer standard (from tables 1, 2 and 3) in a clean, dry or pre-rinsed calibration cup, carefully immerse the probe end of the sonde into the solution. Allow at least 1 minute for temperature equilibration before proceeding.

From the Calibrate menu, select number **4-ISE1 pH** to access the pH calibration choices and then press number **2- 2-Point**. Press **Enter** and input the value of the buffer (7 in this case) at the prompt. Press **Enter** and the current values of all enabled sensors will appear on the screen and change with time as they stabilize in the solution. Observe the readings under pH and when they show no significant change for approximately 30 seconds, press **Enter**. The display will indicate that the calibration is accepted.

After the pH 7 calibration is complete, press **Enter** again, as instructed on the screen, to continue. Rinse the sonde in water and dry the sonde before proceeding to the next step.

Using the correct amount (from tables 1, 2 and 3) of an additional pH buffer standard into a clean, dry or pre-rinsed calibration cup, carefully immerse the probe end of the sonde into the solution. Allow at least 1 minute for temperature equilibration before proceeding.

Press **Enter** and input the value of the second buffer at the prompt. Press **Enter** and the current values of all enabled sensors will appear on the screen and will change with time as they stabilize in the solution. Observe the readings under pH and when they show no significant change for approximately 30 seconds, press **Enter**. After the second calibration point is complete, press **Enter** again, as instructed on the screen, to return to the Calibrate menu.

Rinse the sonde in water and dry. Thoroughly rinse and dry the calibration containers for future use.

*The next calibration instructions are only for the 6820, 6600 and 6920 sondes. If you do not have one of these sondes, you may skip to 2.7, Taking Readings.*

#### AMMONIUM ( $\text{NH}_4^+$ ) , CHLORIDE $\text{Cl}^-$ AND NITRATE ( $\text{NO}_3^-$ ) 3-POINT

**WARNING:** AMMONIUM AND NITRATE SENSORS CAN ONLY BE USED AT DEPTHS OF LESS THAN 50 FEET (15 METERS). USE OF THE SENSORS AT GREATER DEPTHS IS LIKELY TO PERMANENTLY DAMAGE THE SENSOR MEMBRANE.

The calibration procedures for ammonium, nitrate or chloride are similar to pH except for the reagents in the calibration solutions. Suggested values for calibrants are 1 and 100 mg/L of either ammonium-nitrogen ( $\text{NH}_4\text{-N}$ ) or nitrate-nitrogen ( $\text{NO}_3\text{-N}$ ). Suggested values for calibrants are 10 and 1000 mg/L of Chloride ( $\text{Cl}^-$ ).

**NOTE:** The following procedure requires one portion of the high concentration calibrant and two portions of the low concentration calibrant. The high concentration solution and one of the low concentration solutions should be at ambient temperature. The other low concentration solution should be chilled to less than 10°C prior to beginning the procedure.

Place the proper amount of 100 mg/L standard (1000mg/l for chloride) into a clean, dry or pre-rinsed transport cup. Carefully immerse the probe end of the sonde into the solution. Allow at least 1 minute for temperature equilibration before proceeding.

Select number **6-Ammonium**, **7-Nitrate** or number **8- Chloride** to access the appropriate calibration choices. Then select number **3-3-Point**. Press **Enter** and input the concentration value of the standard as requested. Press **Enter** and the current values of all enabled sensors will appear on the screen and will change with time as they stabilize in the solution. Observe the readings under  $\text{NH}_4^+$ ,  $\text{NO}_3^-$ , or  $\text{Cl}^-$ . When they show no significant change for approximately 30 seconds, press **Enter**.

After the first calibration point is complete, proceed as instructed on the screen, to continue. Rinse the sonde in water and dry the sonde prior to the next step.

Place the proper amount of 1 mg/L standard for Ammonium or Nitrate (10 mg/l for Chloride) into a clean, dry or pre-rinsed transport cup. Carefully immerse the probe end of the sonde into the solution. Allow at least 1 minute for temperature equilibration before proceeding.

Press **Enter** and input the concentration value of the standard as requested.

Press **Enter** and the current values of all enabled sensors will appear on the screen and will change with time as they stabilize in the solution. Observe the readings under  $\text{NH}_4^+$ ,  $\text{NO}_3^-$ , or  $\text{Cl}^-$  and when they have show no significant change for approximately 30 seconds, press **Enter**.

After the second value calibration is complete, press **Enter** to continue. Place the proper amount of chilled 1 mg/L standard (10 mg/L for the chloride) into a clean, dry or pre-rinsed calibration cup. Carefully immerse the probe end of the sonde into the solution. Allow at least 5 minutes for temperature equilibration before proceeding.

Press **Enter** and input the concentration value of the standard as requested.

Press **Enter** and the current values of all enabled sensors will appear on the screen and will change with time as they stabilize in the solution. Observe the readings under  $\text{NH}_4^+$ ,  $\text{NO}_3^-$  or  $\text{Cl}^-$  and when they show no significant change for approximately 30 seconds, press **Enter**.

After the third value calibration is complete, press **Enter** to return to the Calibrate menu.

Thoroughly rinse and dry the calibration cups for future use.

**CALIBRATION TIP: HOW TO AVOID DRIFT DURING CALIBRATION OF THE  $\text{NH}_4^+$ ,  $\text{NO}_3^-$  AND  $\text{Cl}^-$  PROBES AFTER pH CALIBRATION.** Exposure to the high ionic content of pH buffers can cause a significant, but temporary, drift in these ISE probes (ammonium, nitrate and chloride probes). Therefore, when calibrating the pH probe, YSI recommends that you use one of the following methods to minimize errors in the subsequent readings:

- Calibrate pH first, immersing all of the probes in the pH buffers. After calibrating pH, place the probes in 100 mg/L nitrate or ammonium standard (1000 mg/L chloride) and monitor the reading. Usually, the reading starts low and may take as long as 30 minutes to reach a stable value. When it does, proceed with the calibration.
- When calibrating pH, remove the probe guard and immerse only the pH and temperature probes in the buffers. You can then calibrate nitrate, ammonium or chloride immediately. This will be virtually impossible if a turbidity probe is installed.

#### TURBIDITY 2-POINT

---

Select **8-Turbidity** from the Calibrate Menu and then **2-2-Point**.

**NOTE:** One standard must be 0 NTU, and this standard must be calibrated first.

To begin the calibration, the correct amount ( from tables 1, 2 and 3) of 0 NTU standard (clear deionized, distilled, or tap water) into the clear calibration cup (provided) or in a glass beaker. With the probe guard installed, immerse the sonde in the water. Input the value 0.00 NTU at the prompt, and press **Enter**. The screen will display real-time readings that will allow you to determine when the readings have stabilized. If you have a mechanically-cleaned turbidity probe installed, activate the wiper 1-2 times by pressing number **3-Clean Optics** as shown on the screen to remove any bubbles. If your probe is not mechanically cleaned, rotate the sonde back and forth in the water to facilitate removal of bubbles. After stabilization is complete, press **Enter** to "confirm" the first calibration and then, as instructed, press **Enter** to continue.

Dry the sonde carefully and then place the sonde in the second turbidity standard (100 NTU is suggested) using the same container as for the 0 NTU standard. Input the correct turbidity value in NTU, press **Enter**, and view the stabilization of the values on the screen in real-time. As above, activate the wiper with the "3" key or manually rotate the sonde to remove bubbles. After the readings have stabilized, press **Enter** to confirm the calibration and then press **Enter** to return to the Calibrate menu.

Thoroughly rinse and dry the calibration cups for future use. For additional information related to calibrating the turbidity sensor, see **Appendix E, Turbidity Measurements**.

## CHLOROPHYLL 1-POINT

---

Select **Optic Chlorophyll** from the Calibrate Menu and then select **Chl  $\mu\text{g/L}$** . Then select **1-1 point**.

**NOTE:** This procedure will zero your fluorescence sensor and use the default sensitivity for calculation of chlorophyll concentration in  $\mu\text{g/L}$ . The default sensitivity is usually within 25 % for any probe. The 1-point calibration will therefore allow quick and easy fluorescence measurements that are only semi-quantitative with regard to chlorophyll. However, the readings will reflect changes in chlorophyll from site to site, or over time at a single site.

To increase the accuracy of your chlorophyll measurements, follow the 2-point or 3-point calibration protocols outlined in **Section 2.9, Sonde Menu**.

Before making any field readings, carefully read Sections 5.12, **Chlorophyll** and **Appendix I, Chlorophyll** about chlorophyll that describe practical aspects of fluorescence measurements.

To begin the calibration, place the correct amount of clear deionized or distilled water, from Tables 1, 2 and 3, into the YSI clear calibration cup provided or in a glass beaker of an appropriate size (600 mL for 6820 and 6920 sondes; 800 mL for the 6600 sonde). With the probe guard installed, immerse the sonde in the water. Input the value 0  $\mu\text{g/L}$  at the prompt, and press **Enter**. The screen will display real-time readings that will allow you to determine when the readings have stabilized. Activate the wiper 1-2 times by pressing number **3-Clean Optics** as shown on the screen to remove any bubbles from the sensor. After stabilization is complete, press **Enter** to "confirm" the calibration and then, as instructed, press **Enter** to return to the Calibrate menu.

Thoroughly rinse and dry the calibration cups for future use. For additional information related to calibrating the chlorophyll sensor, see Sections 5.12, **Chlorophyll** and **Appendix I, Chlorophyll**.

APPENDIX M

LOW-FLOW (MINIMAL DRAWDOWN)  
GROUND-WATER SAMPLING  
PROCEDURES



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United States  
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Office of  
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# Ground Water Issue

## LOW-FLOW (MINIMAL DRAWDOWN) GROUND-WATER SAMPLING PROCEDURES

by Robert W. Puls<sup>1</sup> and Michael J. Barcelona<sup>2</sup>

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1 of pages

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### Background

The Regional Superfund Ground Water Forum is a group of ground-water scientists, representing EPA's Regional Superfund Offices, organized to exchange information related to ground-water remediation at Superfund sites. One of the major concerns of the Forum is the sampling of ground water to support site assessment and remedial performance monitoring objectives. This paper is intended to provide background information on the development of low-flow sampling procedures and its application under a variety of hydrogeologic settings. It is hoped that the paper will support the production of standard operating procedures for use by EPA Regional personnel and other environmental professionals engaged in ground-water sampling.

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### 1. Introduction

The methods and objectives of ground-water sampling to assess water quality have evolved over time. Initially the emphasis was on the assessment of water quality of aquifers as sources of drinking water. Large water-bearing

units were identified and sampled in keeping with objective. These were highly productive aquifers that supplied drinking water via private wells or through public water supply systems. Gradually, with the increasing awareness of subsurface pollution of these water resources, the understanding of complex hydrogeochemical processes which govern the fate and transport of contaminants in the subsurface increased. This increase in understanding was also due to advances in a number of scientific disciplines and improvements in tools used for site characterization and ground-water sampling. Ground-water quality investigations where pollution was detected initially borrowed ideas, methods, and materials for site characterization from the water supply field and water analysis from public health practices. This included the materials and manner in which monitoring wells were installed and the way in which water was brought to the surface, treated, preserved and analyzed. The prevailing conceptual ideas included convenient generalizations of ground-water resources in terms of large and relatively homogeneous hydrologic units. With time it became apparent that conventional water supply generalizations of homogeneity did not adequately represent field data regarding pollution of these subsurface resources. The important role of heterogeneity became increasingly clear not only in geologic terms, but also in terms of complex physical,

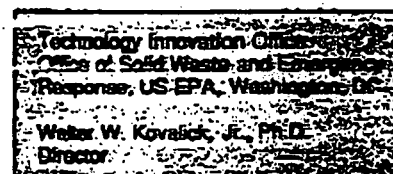
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chemical and biological subsurface processes. With greater appreciation of the role of heterogeneity, it became evident that subsurface pollution was ubiquitous and encompassed the unsaturated zone to the deep subsurface and included unconsolidated sediments, fractured rock, and aquitards or low-yielding or impermeable formations. Small-scale processes and heterogeneities were shown to be important in identifying contaminant distributions and in controlling water and contaminant flow paths.

It is beyond the scope of this paper to summarize all the advances in the field of ground-water quality investigations and remediation, but two particular issues have bearing on ground-water sampling today: aquifer heterogeneity and colloidal transport. Aquifer heterogeneities affect contaminant flow paths and include variations in geology, geochemistry, hydrology and microbiology. As methods and the tools available for subsurface investigations have become increasingly sophisticated and understanding of the subsurface environment has advanced, there is an awareness that in most cases a primary concern for site investigations is characterization of contaminant flow paths rather than entire aquifers. In fact, in many cases, plume thickness can be less than well screen lengths (e.g., 3-6 m) typically installed at hazardous waste sites to detect and monitor plume movement over time. Small-scale differences have increasingly been shown to be important and there is a general trend toward smaller diameter wells and shorter screens.

The hydrogeochemical significance of colloidal-size particles in subsurface systems has been realized during the past several years (Gschwend and Reynolds, 1987; McCarthy and Zachara, 1989; Puls, 1990; Ryan and Gschwend, 1990). This realization resulted from both field and laboratory studies that showed faster contaminant migration over greater distances and at higher concentrations than flow and transport model predictions would suggest (Buddemeier and Hunt, 1988; Enfield and Bengtsson, 1988; Penrose et al., 1990). Such models typically account for interaction between the mobile aqueous and immobile solid phases, but do not allow for a mobile, reactive solid phase. It is recognition of this third phase as a possible means of contaminant transport that has brought increasing attention to the manner in which samples are collected and processed for analysis (Puls et al., 1990; McCarthy and Degueudre, 1993; Backhus et al., 1993; U. S. EPA, 1995). If such a phase is present in sufficient mass, possesses high sorption reactivity, large surface area, and remains stable in suspension, it can serve as an important mechanism to facilitate contaminant transport in many types of subsurface systems.

Colloids are particles that are sufficiently small so that the surface free energy of the particle dominates the bulk free energy. Typically, in ground water, this includes particles with diameters between 1 and 1000 nm. The most commonly observed mobile particles include: secondary clay minerals; hydrous iron, aluminum, and manganese oxides; dissolved and particulate organic materials, and viruses and bacteria.

These reactive particles have been shown to be mobile under a variety of conditions in both field studies and laboratory column experiments, and as such need to be included in monitoring programs where identification of the total mobile contaminant loading (dissolved + naturally suspended particles) at a site is an objective. To that end, sampling methodologies must be used which do not artificially bias naturally suspended particle concentrations.

Currently the most common ground-water purging and sampling methodology is to purge a well using bailers or high speed pumps to remove 3 to 5 casing volumes followed by sample collection. This method can cause adverse impacts on sample quality through collection of samples with high levels of turbidity. This results in the inclusion of otherwise immobile artifactual particles which produce an overestimation of certain analytes of interest (e.g., metals or hydrophobic organic compounds). Numerous documented problems associated with filtration (Danielsson, 1982; Laxen and Chandler, 1982; Horowitz et al., 1992) make this an undesirable method of rectifying the turbidity problem, and include the removal of potentially mobile (contaminant-associated) particles during filtration, thus artificially biasing contaminant concentrations low. Sampling-induced turbidity problems can often be mitigated by using low-flow purging and sampling techniques.

Current subsurface conceptual models have undergone considerable refinement due to the recent development and increased use of field screening tools. So-called hydraulic push technologies (e.g., cone penetrometer, Geoprobe®, QED HydroPunch®) enable relatively fast screening site characterization which can then be used to design and install a monitoring well network. Indeed, alternatives to conventional monitoring wells are now being considered for some hydrogeologic settings. The ultimate design of any monitoring system should however be based upon adequate site characterization and be consistent with established monitoring objectives.

If the sampling program objectives include accurate assessment of the magnitude and extent of subsurface contamination over time and/or accurate assessment of subsequent remedial performance, then some information regarding plume delineation in three-dimensional space is necessary prior to monitoring well network design and installation. This can be accomplished with a variety of different tools and equipment ranging from hand-operated augers to screening tools mentioned above and large drilling rigs. Detailed information on ground-water flow velocity, direction, and horizontal and vertical variability are essential baseline data requirements. Detailed soil and geologic data are required prior to and during the installation of sampling points. This includes historical as well as present soil and geologic logs which accumulate during the site investigation. The use of borehole geophysical techniques is also recommended. With this information (together with other site characterization data) and a clear understanding of sampling

objectives, then appropriate location, screen length, well diameter, slot size, etc. for the monitoring well network can be decided. This is especially critical for new in situ remedial approaches or natural attenuation assessments at hazardous waste sites.

In general, the overall goal of any ground-water sampling program is to collect water samples with no alteration in water chemistry; analytical data thus obtained may be used for a variety of specific monitoring programs depending on the regulatory requirements. The sampling methodology described in this paper assumes that the monitoring goal is to sample monitoring wells for the presence of contaminants and it is applicable whether mobile colloids are a concern or not and whether the analytes of concern are metals (and metal-loids) or organic compounds.

## II. Monitoring Objectives and Design Considerations

The following issues are important to consider prior to the design and implementation of any ground-water monitoring program, including those which anticipate using low-flow purging and sampling procedures.

### A. Data Quality Objectives (DQOs)

Monitoring objectives include four main types: detection, assessment, corrective-action evaluation and resource evaluation, along with *hybrid* variations such as site-assessments for property transfers and water availability investigations. Monitoring objectives may change as contamination or water quality problems are discovered. However, there are a number of common components of monitoring programs which should be recognized as important regardless of initial objectives. These components include:

- 1) Development of a conceptual model that incorporates elements of the regional geology to the local geologic framework. The conceptual model development also includes initial site characterization efforts to identify hydrostratigraphic units and likely flow-paths using a minimum number of borings and well completions;
- 2) Cost-effective and well documented collection of high quality data utilizing simple, accurate, and reproducible techniques; and
- 3) Refinement of the conceptual model based on supplementary data collection and analysis.

These fundamental components serve many types of monitoring programs and provide a basis for future efforts that evolve in complexity and level of spatial detail as purposes and objectives expand. High quality, reproducible data collection is a common goal regardless of program objectives.

High quality data collection implies data of sufficient accuracy, precision, and completeness (i.e., ratio of valid analytical results to the minimum sample number called for by the program design) to meet the program objectives. Accuracy depends on the correct choice of monitoring tools and procedures to minimize sample and subsurface disturbance from collection to analysis. Precision depends on the repeatability of sampling and analytical protocols. It can be assured or improved by replication of sample analyses including blanks, field/lab standards and reference standards.

### B. Sample Representativeness

An important goal of any monitoring program is collection of data that is truly representative of conditions at the site. The term *representativeness* applies to chemical and hydrogeologic data collected via wells, borings, piezometers, geophysical and soil gas measurements, lysimeters, and temporary sampling points. It involves a recognition of the statistical variability of individual subsurface physical properties, and contaminant or major ion concentration levels, while explaining extreme values. Subsurface temporal and spatial variability are facts. Good professional practice seeks to maximize representativeness by using proven accurate and reproducible techniques to define limits on the distribution of measurements collected at a site. However, measures of representativeness are dynamic and are controlled by evolving site characterization and monitoring objectives. An evolutionary site characterization model, as shown in Figure 1, provides a systematic approach to the goal of consistent data collection.

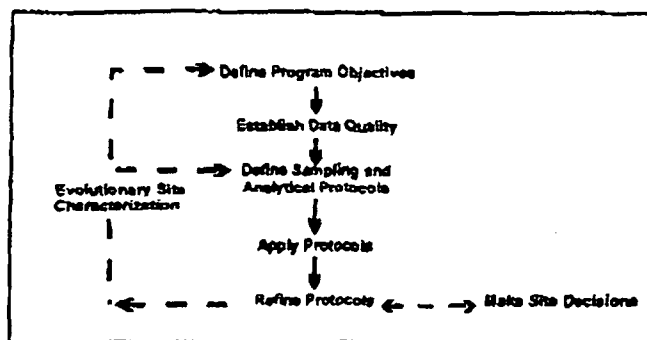


Figure 1. Evolutionary Site Characterization Model

The model emphasizes a recognition of the causes of the variability (e.g., use of inappropriate technology such as using bailers to purge wells; imprecise or operator-dependent methods) and the need to control avoidable errors.

### 1) Questions of Scale

A sampling plan designed to collect representative samples must take into account the potential scale of changes in site conditions through space and time as well as the chemical associations and behavior of the parameters that are targeted for investigation. In subsurface systems, physical (i.e., aquifer) and chemical properties over time or space are not statistically independent. In fact, samples taken in close proximity (i.e., within distances of a few meters) or within short time periods (i.e., more frequently than monthly) are highly auto-correlated. This means that designs employing high-sampling frequency (e.g., monthly) or dense spatial monitoring designs run the risk of redundant data collection and misleading inferences regarding trends in values that aren't statistically valid. In practice, contaminant detection and assessment monitoring programs rarely suffer these over-sampling concerns. In corrective-action evaluation programs, it is also possible that too little data may be collected over space or time. In these cases, false interpretation of the spatial extent of contamination or underestimation of temporal concentration variability may result.

### 2) Target Parameters

Parameter selection in monitoring program design is most often dictated by the regulatory status of the site. However, background water quality constituents, purging indicator parameters, and contaminants, all represent targets for data collection programs. The tools and procedures used in these programs should be equally rigorous and applicable to all categories of data, since all may be needed to determine or support regulatory action.

### C. Sampling Point Design and Construction

Detailed site characterization is central to all decision-making purposes and the basis for this characterization resides in identification of the geologic framework and major hydro-stratigraphic units. Fundamental data for sample point location include: subsurface lithology, head-differences and background geochemical conditions. Each sampling point has a proper use or uses which should be documented at a level which is appropriate for the program's data quality objectives. Individual sampling points may not always be able to fulfill multiple monitoring objectives (e.g., detection, assessment, corrective action).

#### 1) Compatibility with Monitoring Program and Data Quality Objectives

Specifics of sampling point location and design will be dictated by the complexity of subsurface lithology and variability in contaminant and/or geochemical conditions. It should be noted that, regardless of the ground-water sampling approach, few sampling points (e.g., wells, drive-points, screened augers) have zones of influence in excess of a few

feet. Therefore, the spatial frequency of sampling points should be carefully selected and designed.

#### 2) Flexibility of Sampling Point Design

In most cases well-point diameters in excess of 1 7/8 inches will permit the use of most types of submersible pumping devices for low-flow (minimal drawdown) sampling. It is suggested that short (e.g., less than 1.6 m) screens be incorporated into the monitoring design where possible so that comparable results from one device to another might be expected. Short, of course, is relative to the degree of vertical water quality variability expected at a site.

#### 3) Equilibration of Sampling Point

Time should be allowed for equilibration of the well or sampling point with the formation after installation. Placement of well or sampling points in the subsurface produces some disturbance of ambient conditions. Drilling techniques (e.g., auger, rotary, etc.) are generally considered to cause more disturbance than direct-push technologies. In either case, there may be a period (i.e., days to months) during which water quality near the point may be distinctly different from that in the formation. Proper development of the sampling point and adjacent formation to remove fines created during emplacement will shorten this water quality recovery period.

### III. Definition of Low-Flow Purging and Sampling

It is generally accepted that water in the well casing is non-representative of the formation water and needs to be purged prior to collection of ground-water samples. However, the water in the screened interval may indeed be representative of the formation, depending upon well construction and site hydrogeology. Wells are purged to some extent for the following reasons: the presence of the air interface at the top of the water column resulting in an oxygen concentration gradient with depth, loss of volatiles up the water column, leaching from or sorption to the casing or filter pack, chemical changes due to clay seals or backfill, and surface infiltration.

Low-flow purging, whether using portable or dedicated systems, should be done using pump-intake located in the middle or slightly above the middle of the screened interval. Placement of the pump too close to the bottom of the well will cause increased entrainment of solids which have collected in the well over time. These particles are present as a result of well development, prior purging and sampling events, and natural colloidal transport and deposition. Therefore, placement of the pump in the middle or toward the top of the screened interval is suggested. Placement of the pump at the top of the water column for sampling is only recommended in unconfined aquifers, screened across the water table, where this is the desired sampling point. Low-

flow purging has the advantage of minimizing mixing between the overlying stagnant casing water and water within the screened interval.

### A. Low-Flow Purging and Sampling

Low-flow refers to the velocity with which water enters the pump intake and that is imparted to the formation pore water in the immediate vicinity of the well screen. It does not necessarily refer to the flow rate of water discharged at the surface which can be affected by flow regulators or restrictions. Water level drawdown provides the best indication of the stress imparted by a given flow-rate for a given hydrological situation. The objective is to pump in a manner that minimizes stress (drawdown) to the system to the extent practical taking into account established site sampling objectives. Typically, flow rates on the order of 0.1 - 0.5 L/min are used, however this is dependent on site-specific hydrogeology. Some extremely coarse-textured formations have been successfully sampled in this manner at flow rates to 1 L/min. The effectiveness of using low-flow purging is intimately linked with proper screen location, screen length, and well construction and development techniques. The reestablishment of natural flow paths in both the vertical and horizontal directions is important for correct interpretation of the data. For high resolution sampling needs, screens less than 1 m should be used. Most of the need for purging has been found to be due to passing the sampling device through the overlying casing water which causes mixing of these stagnant waters and the dynamic waters within the screened interval. Additionally, there is disturbance to suspended sediment collected in the bottom of the casing and the displacement of water out into the formation immediately adjacent to the well screen. These disturbances and impacts can be avoided using dedicated sampling equipment, which precludes the need to insert the sampling device prior to purging and sampling.

Isolation of the screened interval water from the overlying stagnant casing water may be accomplished using low-flow minimal drawdown techniques. If the pump intake is located within the screened interval, most of the water pumped will be drawn in directly from the formation with little mixing of casing water or disturbance to the sampling zone. However, if the wells are not constructed and developed properly, zones other than those intended may be sampled. At some sites where geologic heterogeneities are sufficiently different within the screened interval, higher conductivity zones may be preferentially sampled. This is another reason to use shorter screened intervals, especially where high spatial resolution is a sampling objective.

### B. Water Quality Indicator Parameters

It is recommended that water quality indicator parameters be used to determine purging needs prior to sample collection in each well. Stabilization of parameters such as pH, specific conductance, dissolved oxygen, oxida-

tion-reduction potential, temperature and turbidity should be used to determine when formation water is accessed during purging. In general, the order of stabilization is pH, temperature, and specific conductance, followed by oxidation-reduction potential, dissolved oxygen and turbidity. Temperature and pH, while commonly used as purging indicators, are actually quite insensitive in distinguishing between formation water and stagnant casing water; nevertheless, these are important parameters for data interpretation purposes and should also be measured. Performance criteria for determination of stabilization should be based on water-level drawdown, pumping rate and equipment specifications for measuring indicator parameters. Instruments are available which utilize in-line flow cells to continuously measure the above parameters.

It is important to establish specific well stabilization criteria and then consistently follow the same methods thereafter, particularly with respect to drawdown, flow rate and sampling device. Generally, the time or purge volume required for parameter stabilization is independent of well depth or well volumes. Dependent variables are well diameter, sampling device, hydrogeochemistry, pump flow rate, and whether the devices are used in a portable or dedicated manner. If the sampling device is already in place (i.e., dedicated sampling systems), then the time and purge volume needed for stabilization is much shorter. Other advantages of dedicated equipment include less purge water for waste disposal, much less decontamination of equipment, less time spent in preparation of sampling as well as time in the field, and more consistency in the sampling approach which probably will translate into less variability in sampling results. The use of dedicated equipment is strongly recommended at wells which will undergo routine sampling over time.

If parameter stabilization criteria are too stringent, then minor oscillations in indicator parameters may cause purging operations to become unnecessarily protracted. It should also be noted that turbidity is a very conservative parameter in terms of stabilization. Turbidity is always the last parameter to stabilize. Excessive purge times are invariably related to the establishment of too stringent turbidity stabilization criteria. It should be noted that natural turbidity levels in ground water may exceed 10 nephelometric turbidity units (NTU).

### C. Advantages and Disadvantages of Low-Flow (Minimum Drawdown) Purging

In general, the advantages of low-flow purging include:

- samples which are representative of the mobile load of contaminants present (dissolved and colloid-associated);
- minimal disturbance of the sampling point thereby minimizing sampling artifacts;
- less operator variability, greater operator control;

- reduced stress on the formation (minimal drawdown);
- less mixing of stagnant casing water with formation water;
- reduced need for filtration and, therefore, less time required for sampling;
- smaller purging volume which decreases waste disposal costs and sampling time;
- better sample consistency; reduced artificial sample variability.

Some disadvantages of low-flow purging are:

- higher initial capital costs,
- greater set-up time in the field,
- need to transport additional equipment to and from the site,
- increased training needs,
- resistance to change on the part of sampling practitioners,
- concern that new data will indicate a *change in conditions* and trigger an *action*.

#### IV. Low-Flow (Minimal Drawdown) Sampling Protocols

The following ground-water sampling procedure has evolved over many years of experience in ground-water sampling for organic and inorganic compound determinations and as such summarizes the authors' (and others) experiences to date (Barcelona et al., 1984, 1994; Barcelona and Helfrich, 1988; Puls and Barcelona, 1989; Puls et al. 1990, 1992; Puls and Powell, 1992; Puls and Paul, 1995). High-quality chemical data collection is essential in ground-water monitoring and site characterization. The primary limitations to the collection of *representative* ground-water samples include: mixing of the stagnant casing and *fresh* screen waters during insertion of the sampling device or ground-water level measurement device; disturbance and resuspension of settled solids at the bottom of the well when using high pumping rates or raising and lowering a pump or bailer; introduction of atmospheric gases or degassing from the water during sample handling and transfer, or inappropriate use of vacuum sampling device, etc.

##### A. Sampling Recommendations

Water samples should not be taken immediately following well development. Sufficient time should be allowed for the ground-water flow regime in the vicinity of the monitoring well to stabilize and to approach chemical equilibrium with the well construction materials. This lag time will depend on site conditions and methods of installation but often exceeds one week.

Well purging is nearly always necessary to obtain samples of water flowing through the geologic formations in the screened interval. Rather than using a general but arbitrary guideline of purging three casing volumes prior to

sampling, it is recommended that an in-line water quality measurement device (e.g., flow-through cell) be used to establish the stabilization time for several parameters (e.g., pH, specific conductance, redox, dissolved oxygen, turbidity) on a well-specific basis. Data on pumping rate, drawdown, and volume required for parameter stabilization can be used as a guide for conducting subsequent sampling activities.

The following are recommendations to be considered before, during and after sampling:

- use low-flow rates (<0.5 L/min), during both purging and sampling to maintain minimal drawdown in the well;
- maximize tubing wall thickness, minimize tubing length;
- place the sampling device intake at the desired sampling point;
- minimize disturbances of the stagnant water column above the screened interval during water level measurement and sampling device insertion;
- make proper adjustments to stabilize the flow rate as soon as possible;
- monitor water quality indicators during purging;
- collect unfiltered samples to estimate contaminant loading and transport potential in the subsurface system.

##### B. Equipment Calibration

Prior to sampling, all sampling device and monitoring equipment should be calibrated according to manufacturer's recommendations and the site Quality Assurance Project Plan (QAPP) and Field Sampling Plan (FSP). Calibration of pH should be performed with at least two buffers which bracket the expected range. Dissolved oxygen calibration must be corrected for local barometric pressure readings and elevation.

##### C. Water Level Measurement and Monitoring

It is recommended that a device be used which will least disturb the water surface in the casing. Well depth should be obtained from the well logs. Measuring to the bottom of the well casing will only cause resuspension of settled solids from the formation and require longer purging times for turbidity equilibration. Measure well depth after sampling is completed. The water level measurement should be taken from a permanent reference point which is surveyed relative to ground elevation.

##### D. Pump Type

The use of low-flow (e.g., 0.1-0.5 L/min) pumps is suggested for purging and sampling all types of samples. All pumps have some limitation and these should be investigated with respect to application at a particular site. Bailers are inappropriate devices for low-flow sampling.

## 1) General Considerations

There are no unusual requirements for ground-water sampling devices when using low-flow, minimal drawdown techniques. The major concern is that the device give consistent results and minimal disturbance of the sample across a range of low flow rates (i.e., < 0.5 L/min). Clearly, pumping rates that cause minimal to no drawdown in one well could easily cause significant drawdown in another well finished in a less transmissive formation. In this sense, the pump should not cause undue pressure or temperature changes or physical disturbance on the water sample over a reasonable sampling range. Consistency in operation is critical to meet accuracy and precision goals.

## 2) Advantages and Disadvantages of Sampling Devices

A variety of sampling devices are available for low-flow (minimal drawdown) purging and sampling and include peristaltic pumps, bladder pumps, electrical submersible pumps, and gas-driven pumps. Devices which lend themselves to both dedication and consistent operation at definable low-flow rates are preferred. It is desirable that the pump be easily adjustable and operate reliably at these lower flow rates. The peristaltic pump is limited to shallow applications and can cause degassing resulting in alteration of pH, alkalinity, and some volatiles loss. Gas-driven pumps should be of a type that does not allow the gas to be in direct contact with the sampled fluid.

Clearly, bailers and other grab type samplers are ill-suited for low-flow sampling since they will cause repeated disturbance and mixing of stagnant water in the casing and the dynamic water in the screened interval. Similarly, the use of inertial lift foot-valve type samplers may cause too much disturbance at the point of sampling. Use of these devices also tends to introduce uncontrolled and unacceptable operator variability.

Summaries of advantages and disadvantages of various sampling devices are listed in Herzog et al. (1991), U. S. EPA (1992), Parker (1994) and Thurnblad (1994).

## E. Pump Installation

Dedicated sampling devices (left in the well) capable of pumping and sampling are preferred over any other type of device. Any portable sampling device should be slowly and carefully lowered to the middle of the screened interval or slightly above the middle (e.g., 1-1.5 m below the top of a 3 m screen). This is to minimize excessive mixing of the stagnant water in the casing above the screen with the screened interval zone water, and to minimize resuspension of solids which will have collected at the bottom of the well. These two disturbance effects have been shown to directly affect the time required for purging. There also appears to be a direct correlation between size of portable sampling devices relative to the well bore and resulting purge volumes and times. The key is to minimize disturbance of water and solids in the well casing.

## F. Filtration

Decisions to filter samples should be dictated by sampling objectives rather than as a fix for poor sampling practices, and field-filtering of certain constituents should not be the default. Consideration should be given as to what the application of field-filtration is trying to accomplish. For assessment of truly dissolved (as opposed to operationally dissolved [i.e., samples filtered with 0.45  $\mu$ m filters]) concentrations of major ions and trace metals, 0.1  $\mu$ m filters are recommended although 0.45  $\mu$ m filters are normally used for most regulatory programs. Alkalinity samples must also be filtered if significant particulate calcium carbonate is suspected, since this material is likely to impact alkalinity titration results (although filtration itself may alter the CO<sub>2</sub> composition of the sample and, therefore, affect the results).

Although filtration may be appropriate, filtration of a sample may cause a number of unintended changes to occur (e.g. oxidation, aeration) possibly leading to filtration-induced artifacts during sample analysis and uncertainty in the results. Some of these unintended changes may be unavoidable but the factors leading to them must be recognized. Deleterious effects can be minimized by consistent application of certain filtration guidelines. Guidelines should address selection of filter type, media, pore size, etc. in order to identify and minimize potential sources of uncertainty when filtering samples.

In-line filtration is recommended because it provides better consistency through less sample handling, and minimizes sample exposure to the atmosphere. In-line filters are available in both disposable (barrel filters) and non-disposable (in-line filter holder, flat membrane filters) formats and various filter pore sizes (0.1-5.0  $\mu$ m). Disposable filter cartridges have the advantage of greater sediment handling capacity when compared to traditional membrane filters. Filters must be pre-rinsed following manufacturer's recommendations. If there are no recommendations for rinsing, pass through a minimum of 1 L of ground water following purging and prior to sampling. Once filtration has begun, a filter cake may develop as particles larger than the pore size accumulate on the filter membrane. The result is that the effective pore diameter of the membrane is reduced and particles smaller than the stated pore size are excluded from the filtrate. Possible corrective measures include prefiltering (with larger pore size filters), minimizing particle loads to begin with, and reducing sample volume.

## G. Monitoring of Water Level and Water Quality Indicator Parameters

Check water level periodically to monitor drawdown in the well as a guide to flow rate adjustment. The goal is minimal drawdown (<0.1 m) during purging. This goal may be difficult to achieve under some circumstances due to geologic heterogeneities within the screened interval, and may require adjustment based on site-specific conditions and personal experience. In-line water quality indicator parameters should be continuously monitored during purging. The water quality

indicator parameters monitored can include pH, redox potential, conductivity, dissolved oxygen (DO) and turbidity. The last three parameters are often most sensitive. Pumping rate, drawdown, and the time or volume required to obtain stabilization of parameter readings can be used as a future guide to purge the well. Measurements should be taken every three to five minutes if the above suggested rates are used. Stabilization is achieved after all parameters have stabilized for three successive readings. In lieu of measuring all five parameters, a minimum subset would include pH, conductivity, and turbidity or DO. Three successive readings should be within  $\pm 0.1$  for pH,  $\pm 3\%$  for conductivity,  $\pm 10$  mv for redox potential, and  $\pm 10\%$  for turbidity and DO. Stabilized purge indicator parameter trends are generally obvious and follow either an exponential or asymptotic change to stable values during purging. Dissolved oxygen and turbidity usually require the longest time for stabilization. The above stabilization guidelines are provided for rough estimates based on experience.

#### H. Sampling, Sample Containers, Preservation and Decontamination

Upon parameter stabilization, sampling can be initiated. If an in-line device is used to monitor water quality parameters, it should be disconnected or bypassed during sample collection. Sampling flow rate may remain at established purge rate or may be adjusted slightly to minimize aeration, bubble formation, turbulent filling of sample bottles, or loss of volatiles due to extended residence time in tubing. Typically, flow rates less than 0.5 L/min are appropriate. The same device should be used for sampling as was used for purging. Sampling should occur in a progression from least to most contaminated well, if this is known. Generally, volatile (e.g., solvents and fuel constituents) and gas sensitive (e.g.,  $\text{Fe}^{2+}$ ,  $\text{CH}_4$ ,  $\text{H}_2\text{S}/\text{HS}^-$ , alkalinity) parameters should be sampled first. The sequence in which samples for most inorganic parameters are collected is immaterial unless filtered (dissolved) samples are desired. Filtering should be done last and in-line filters should be used as discussed above. During both well purging and sampling, proper protective clothing and equipment must be used based upon the type and level of contaminants present.

The appropriate sample container will be prepared in advance of actual sample collection for the analytes of interest and include sample preservative where necessary. Water samples should be collected directly into this container from the pump tubing.

Immediately after a sample bottle has been filled, it must be preserved as specified in the site (QAPP). Sample preservation requirements are based on the analyses being performed (use site QAPP, FSP, RCRA guidance document [U. S. EPA, 1992] or EPA SW-346 [U. S. EPA, 1982]). It may be advisable to add preservatives to sample bottles in a controlled setting prior to entering the field in order to reduce the chances of improperly preserving sample bottles or

introducing field contaminants into a sample bottle while adding the preservatives.

The preservatives should be transferred from the chemical bottle to the sample container using a disposable polyethylene pipet and the disposable pipet should be used only once and then discarded.

After a sample container has been filled with ground water, a Teflon™ (or tin)-lined cap is screwed on tightly to prevent the container from leaking. A sample label is filled out as specified in the FSP. The samples should be stored inverted at 4°C.

Specific decontamination protocols for sampling devices are dependent to some extent on the type of device used and the type of contaminants encountered. Refer to the site QAPP and FSP for specific requirements.

#### I. Blanks

The following blanks should be collected:

- (1) field blank: one field blank should be collected from each source water (distilled/deionized water) used for sampling equipment decontamination or for assisting well development procedures.
- (2) equipment blank: one equipment blank should be taken prior to the commencement of field work, from each set of sampling equipment to be used for that day. Refer to site QAPP or FSP for specific requirements.
- (3) trip blank: a trip blank is required to accompany each volatile sample shipment. These blanks are prepared in the laboratory by filling a 40-mL volatile organic analysis (VOA) bottle with distilled/deionized water.

#### V. Low-Permeability Formations and Fractured Rock

The overall sampling program goals or sampling objectives will drive how the sampling points are located, installed, and choice of sampling device. Likewise, site-specific hydrogeologic factors will affect these decisions. Sites with very low permeability formations or fractures causing discrete flow channels may require a unique monitoring approach. Unlike water supply wells, wells installed for ground-water quality assessment and restoration programs are often installed in low water-yielding settings (e.g., clays, silts). Alternative types of sampling points and sampling methods are often needed in these types of environments, because low-permeability settings may require extremely low-flow purging (<0.1 L/min) and may be technology-limited. Where devices are not readily available to pump at such low flow rates, the primary consideration is to avoid dewatering of

the well screen. This may require repeated recovery of the water during purging while leaving the pump in place within the well screen.

Use of low-flow techniques may be impractical in these settings, depending upon the water recharge rates. The sampler and the end-user of data collected from such wells need to understand the limitations of the data collected; i.e., a strong potential for underestimation of actual contaminant concentrations for volatile organics, potential false negatives for filtered metals and potential false positives for unfiltered metals. It is suggested that comparisons be made between samples recovered using low-flow purging techniques and samples recovered using passive sampling techniques (i.e., two sets of samples). Passive sample collection would essentially entail acquisition of the sample with no or very little purging using a dedicated sampling system installed within the screened interval or a passive sample collection device.

#### A. Low-Permeability Formations (<0.1 L/min recharge)

##### 1. Low-Flow Purging and Sampling with Pumps

- a. "portable or non-dedicated mode" - Lower the pump (one capable of pumping at <0.1 L/min) to mid-screen or slightly above and set in place for minimum of 48 hours (to lessen purge volume requirements). After 48 hours, use procedures listed in Part IV above regarding monitoring water quality parameters for stabilization, etc., but do not dewater the screen. If excessive drawdown and slow recovery is a problem, then alternate approaches such as those listed below may be better.
- b. "dedicated mode" - Set the pump as above at least a week prior to sampling; that is, operate in a dedicated pump mode. With this approach significant reductions in purge volume should be realized. Water quality parameters should stabilize quite rapidly due to less disturbance of the sampling zone.

##### 2. Passive Sample Collection

Passive sampling collection requires insertion of the device into the screened interval for a sufficient time period to allow flow and sample equilibration before extraction for analysis. Conceptually, the extraction of water from low yielding formations seems more akin to the collection of water from the unsaturated zone and passive sampling techniques may be more appropriate in terms of obtaining "representative" samples. Satisfying usual sample volume requirements is typically a problem with this approach and some latitude will be needed on the part of regulatory entities to achieve sampling objectives.

#### B. Fractured Rock

In fractured rock formations, a low-flow to zero purging approach using pumps in conjunction with packers to isolate the sampling zone in the borehole is suggested. Passive multi-layer sampling devices may also provide the most "representative" samples. It is imperative in these settings to identify flow paths or water-producing fractures prior to sampling using tools such as borehole flowmeters and/or other geophysical tools.

After identification of water-bearing fractures, install packer(s) and pump assembly for sample collection using low-flow sampling in "dedicated mode" or use a passive sampling device which can isolate the identified water-bearing fractures.

#### VI. Documentation

The usual practices for documenting the sampling event should be used for low-flow purging and sampling techniques. This should include, at a minimum: information on the conduct of purging operations (flow-rate, drawdown, water-quality parameter values, volumes extracted and times for measurements), field instrument calibration data, water sampling forms and chain of custody forms. See Figures 2 and 3 and "Ground Water Sampling Workshop - A Workshop Summary" (U. S. EPA, 1995) for example forms and other documentation suggestions and information. This information coupled with laboratory analytical data and validation data are needed to judge the "useability" of the sampling data.

#### VII. Notice

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**Sampling Personnel** \_\_\_\_\_

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